Watershed '96

Contents - Sessions 41 - 60

SESSION 41

SESSION 42

SESSION 43

SESSION 44

SESSION 48

SESSION 49

SESSION 50

SESSION 51

SESSION 52

SESSION 53

SESSION 54

SESSION 55

SESSION 56

SESSION 57

SESSION 58

SESSION 59

SESSION 60

Emerging Trends and Future Issues

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Introduction

Previous papers concerning "Changing Management of the Colorado River" have provided an overview of the Colorado River Basin, its development for flood control, water supply and power generation, the legal framework or "Law of the River" that guides operations and use of the Colorado River, discussed river operations and the processes such as the annual operating plan and long-term operating criteria, and identified more recent issues and needs voiced by environmental, Native American, and other public interests that relate to use and management of the Colorado River. This paper will describe and discuss some of the key emerging and future management challenges facing the U.S. Bureau of Reclamation (Reclamation) as a prominent player in the resolution of water management issues on the Colorado and offer possible ways to meet these challenges.

Development and management of the Colorado River during this century has been based primarily on activities that would help meet beneficial consumptive use needs by implementing actions associated with taming the Colorado River and providing reliable and adequate water supplies for large irrigation and municipal and industrial projects in the arid West. As a result, the Colorado River Basin is dotted with large dams and associated reservoirs, diversion dams, and distribution systems and is often described as the most closely regulated and controlled river in the United States. Likewise, development of the legal framework or "Law of the River" that divided and established water apportionments among the Basin States, and determined the kinds and priorities of use, was also based on beneficial consumptive use.

The results of actions to complete extensive water development projects and a legal framework for operating the Colorado were extremely successful in meeting the needs of a developing West. Power generation, while typically being given a priority of "incidental to other uses" has none the less been a major factor in Colorado River management because of its role in providing revenues for funding the construction and operation of dams and because of its direct effect on downstream river flows. The integration of these uses have been refined over many years by working with public needs toward acceptable solutions.

So why is the management of the Colorado River System faced with a need to change? Two reasons: increasing consumptive uses such as municipal and industrial are competing with irrigated agriculture; and nonconsumptive environmental and recreational uses are competing with existing and new consumptive uses. While the Colorado River is over-allocated by some accounts, there exist many unused entitlements such as the under-developed Upper Basin and partially quantified Native American water rights. One of the key conflicts of the river is that all of the "allocation amounts" depend on consumptive uses and many of the more contemporary needs are in-stream flows for the Endangered Species Act (ESA) compliance, other fish, recreation, or esthetic uses. At the heart of the current debate is the hope that there are additional water supplies to meet future consumptive uses and some parties may be willing to test the law to see if those supplies can be delivered for their use within the existing law. Further, in 1922, Compact negotiators divided the Colorado River based on an estimated water supply of 18 MAF/yr, while current estimates of average annual flow are closer to 15 MAF/yr. This in itself will continue to present a greater challenge to meet all demands as the Upper Colorado River Basin develops its consumptive use allocation.

The concerns and requests to manage the Colorado River to protect and/or benefit these numerous uses cause the setting to become more complex, contentious, and make "business as usual" a thing of the past. The following sections focus on specific and key issues that characterize the nature and magnitude of the challenge facing agencies and managers of the Colorado River and its resources.

Water Marketing and Water Exchanges

As previously mentioned, the waters of the Colorado River are fully-allocated and, in fact, the Colorado River is over-allocated based on estimates of the average annual water supply. The demand for water for beneficial consumptive use is rapidly reaching the annual apportioned supply in the Lower Colorado River Basin.

To further complicate this, use within the three Lower Basin states differs significantly. Consumptive use within California has exceeded its apportionment for several years because of under utilization in Arizona and Nevada. Nevada, which was apportioned much less water (0.3 MAF) than either Arizona (2.8 MAF) or California (4.4 MAF), projects that it will run out of Colorado River water soon after the turn of the century because of explosive growth in southern Nevada. Arizona, on the other hand, currently has a significant unused apportionment because of less than expected agricultural use of water from the Central Arizona Project.

To satisfy the Lower Basin needs, some have been focusing on the unused allocation in the Upper Basin. The Upper Basin has developed the use of its water supplies much more slowly. In fact, current projections don't show full utilization until at least the year 2060. Only New Mexico is near its entitled use. Future population growth in Western Colorado and Utah is the likely source of increased use in these two states, while Wyoming has limited potential for additional use.

One state, Utah, has been entertaining the thought of leasing some of their unused entitlement, but many are concerned that this approach could some day result in the loss of its water right under the traditional western water law theory of "use it or lose it." This type of water marketing has been termed by some as "water flowing toward money." Water is truly as valuable as gold to these Western states.

So what does the future hold in terms of marketing and exchanges? The current and likely future federal position is to encourage voluntary water marketing through transfers on both an inter- and intra-state basis. Needs of the more populous states are now forcing the Secretary of the Interior to consider creative marketing and exchanges to meet contemporary needs.

Intra-state transfers offer good potential to meet changing demands for use such as exist in California. For example, Southern California (including the greater Los Angeles and San Diego areas) depends on water from Northern California through the State Water Project, Owens Valley, and the Colorado River. Likewise, exports out of the Colorado Basin furnish major areas in Colorado and Utah with municipal and irrigation supplies.

Agricultural use dominates current use of Colorado River water and accounts for more than 80 percent of consumptive use. Discussions and proposals have periodically surfaced and likely will continue in the future to transfer high priority water allocated to California agricultural areas such as the Imperial Valley to Southern California urban areas through existing or new aqueducts by changing the point of diversion of Colorado River water. The urban areas would, in turn, fund water conservation improvements that would result in water savings and more efficient use in the Imperial Valley and possibly sustain current agricultural uses.

Another challenge in doing this is to assess and protect environmental values and needs such as wetlands and river habitats along the Colorado that might be impacted because of changes in points of diversions. Environmental groups are keenly interested in this aspect of any exchange.

In summary, many believe the goal of successful intra-state water marketing or transfers is to keep traditional consumptive uses whole while providing additional supplies for urban purposes. However, it is more likely that some existing uses will be reduced in the future as demands for new uses increase. Public demands and opinion play an important role in shaping policies which govern such transfers of water. Each of the states will face this issue as urbanization continues.

Inter-state marketing between the basins has been a controversial issue for many years. Many view it as being prohibited by the 1922 Colorado River Compact. Federal approval of such proposals would likely depend on unanimous support by the Basin States.

Inter-state marketing or transfer of unused apportionments presents a more difficult challenge because of the fear by all Basin States that such arrangements may lead to a permanent loss of their entitlements to use Colorado River water. One approach that may work and is looked favorably upon by Reclamation in the Lower Basin is to bank unused annual apportionments in reservoirs such as Lake Mead and then market this water to other Basin States on an interim basis. The details under which such arrangements would be governed are very contentious and presently not resolved.

Modification of Dam and River Operations to Meet Environmental and Other Nontraditional Uses

The emergence of demands to modify or reoperate and manage the major facilities such as the Glen Canyon and Hoover Dam and powerplants to meet "public good" uses, such as environmental and recreational uses, is likely to continue to grow in significance in future actions along the Colorado River. The previous papers have discussed processes that involve consideration of endangered species and associated critical habitat in planning for future management of the Colorado River.

Unless significant future changes occur in the "Law of the River," the most typical approach will be to refine operations to better meet these needs. For example, the annual operating plan is generally based on projected water needs from downstream uses, existing water supply in reservoirs, and projected runoffs from basin snowpack. Actual monthly schedules are developed by seeking a balance of the benefits to the various authorized project uses. Dams and hydroelectric facilities in turn are operated to meet water orders and integrate power generation and marketing potential. The actual schedules for release through Colorado River dams has been, or could be, modified; however, this will impact power generation and marketing.

Tradeoffs such as these have already occurred for specific reasons such as beach building, recovery of endangered species, special recreation events, or emergency needs below Flaming Gorge, Aspinall, Navajo, Glen Canyon, and Hoover Dams. The major impact of such tradeoffs has been to power uses, although this could also impact the water users because of the use of power revenues to fund, construct, and operate the dams on the Colorado River.

The ESA has played a major role in changing historic operational practices. It has forced the evaluation of the operation of virtually every reservoir in the Basin, which is having potential impacts on most of the other project functions for which those reservoirs were built. Conflicts are rapidly rising among those wishing to store and release water for consumptive use, those interested in flood control and the operation of reservoirs for the benefit of endangered species. The most prominent philosophy seems to be that of restoring "natural hydrographs," the elimination of which was one of the purposes and outcomes of the building and operation of reservoirs.

Some fear that the strong language of the ESA could overrule any attempt to achieve a balance between uses. Despite this possibility, Reclamation has sought solutions which attempt to achieve the purposes of the ESA while continuing to meet the needs of the other uses. Recovery implementation programs serve as a mechanism to bring all parties to the table for discussions and planning to achieve this goal. Sound biological determinations and trust to find long-term solutions seem to be the key methods for best implementing the ESA as currently written.

Native American Resources and Water Rights

The issue of the Native Americans pursuing and utilizing their water rights could be an exciting one in the future. The Native Americans living in the basin have long contended that their ancestors were not at the barginning table when such important agreements as the upper and lower basin compacts were negotiated. As such they do not feel as compelled to abide by their outcomes. Some suggest that all of their entitlements are outside the agreements. In contrast, many non-Indian parties feel that the interests of the Indians were represented by the federal government under the trust responsibilities outlined in treaties. For example a scenario could develop where a tribe and a water entity within a basin state agree the tribe will deliver a quantity of water to them for a fee and the only way the tribe has of conveying the water is through federal facilities. The tribe in turn requests the Secretary of the Interior to help deliver the water. The Department of the Interior would feel compelled to assist the tribes through trust responsibilities and their soverign status. The outcome may be a "protracted litigation process."

Many positive strides have been made by including Native Americans in discussions on Colorado River issues in the basin. They have become full partners in decision-making processes as evidenced by efforts like Glen Canyon EIS. A very large part of the solution and a challenge in the future will be to increase participation , to the extent possible, by Native Americans in all process so all parties can continue to understand each others needs. It will only be through dialogue that barriers and misconceptions can be removed to allow meaningful compromise.

River Operations

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Introduction

The Colorado River watershed drains about 250,000 square miles, and runs about 1,400 miles from its headwaters in Colorado to its mouth in the Sea of Cortez. The average annual virgin flow is about 15 million acre-feet of water measured at Lees Ferry. The water is delivered to about 1.4 million acres of agricultural land in the United States and Mexico, and to 20 million people for municipal and industrial use in the United States. The annual gross power generation from Reclamation dams on the Colorado River is approximately 10 million megawatt hours. Annual usage is apportioned as follows: 7.5 MAF to the Upper Basin; 7.5 MAF to the Lower Basin; and 1.5 MAF to Mexico.

The development of the Colorado River has resulted in its being one of the most controlled river systems in North America. Construction of major dams with power and water delivery systems by the U.S. Bureau of Reclamation (Reclamation) began early in the twentieth century. The management of these facilities and systems has been assigned by federal laws to Reclamation. These management activities consist of developing and administering water and power contracts, allocating supplies for and balancing the numerous uses of project water, and facility development, operation, and maintenance.

The operation of the Colorado River is governed by a system of laws, compacts, contracts and international treaties collectively termed the "law of the river." This system was developed to accommodate the development of the southwestern United States and Mexico. The usual conflicts over the water of the West are reflected in the history of this system, as is the farsightedness of the early political leaders. Even so, the system must remain responsive to needs of western development which have exceeded the vision of even the most farsighted pioneers. Fortunately, the river system can meet some of these increasing and competing needs through the application of technological advances. Further accommodation must occur through creative management strategies that comport with the "law of the river."

The recent developments and improvements in the operation of the Colorado River system stem from a desire to provide the public with the greatest overall benefit from the watershed. Recent improvements in the management of the river fall into the broad categories of (1) improved operational modeling tools, (2) an expanded decision-making process, and (3) implementation of management techniques to increase total overall benefits from the water projects on the Colorado River.

Improved Operational Modeling Tools

State of the art data acquisition and processing systems allow more numerous and complicated analyses of system operation scenarios. Decisions based on such analyses tend to be better informed, with greater attention paid to the myriad array of operational strategies and risks. Better understanding of these risks allows us to keep the public better informed regarding operations. The following are some initiatives which are playing key roles in our improvement process.

Decision Support Systems for Water Resources Management

The Lower and Upper Colorado Regions are participating in a joint program to develop decision support systems (DSS) for water resources management of the Colorado River. The program includes the development and implementation of a suite of models and databases. All products are being developed to be as generic as possible to allow for future use by other Reclamation regions and area offices. The DSS will present a consistent view of the historical, current, and projected state of the river system through a graphical user interface.

Reclamation, once primarily a water project construction agency, is now focused on the effective management of water resources to meet multiple objectives. These management decisions tend to be complex, with sometimes uncertain consequences and with significant long-lasting impacts. These decisions require flexible, comprehensive decision support tools that display timely and accurate information to water managers. To meet these objectives, we have developed a product to accomplish the following major tasks:

- Develop a general-purpose modeling framework.
- Interactive model building and editing.
- Interactive selection of object behavior (from a library of behaviors).
- Interactive constraint and operating policy specification and modification.

- Interactive time step and time horizon selection.
- Interactive model control selection.
- Water quality modeling (including temperature, dissolved oxygen, salinity).

This product, the Power and Reservoir Systems Model, is currently under the last stages of development at the University of Colorado's Center for Advanced Decision Support for Water and Environmental Systems. This product is currently installed in the regional offices and at Hoover Dam and is being tested as part of the product development. The development is funded by Reclamation, the Tennessee Valley Authority, and the Electric Power Research Institute.

Geographic Information Systems

Within the last 3 years, both the Upper and Lower Colorado Regions have improved technically by adding Geographic Information Systems (GIS) and Remote Sensing (RS) expertise in support of Reclamation's role in managing natural and cultural resources. The GIS and RS teams are applying geospatial information, applications, and analyses to areas of the entire Colorado River Basin.

Current GIS technology is presently being applied toward accurate land inventories, consumptive use determination, archaeological recordation, and fisheries improvement programs. Applications using these technologies are available for other program areas such as environment, water conservation, hazardous waste-site characterization, engineering support, and geology.

Lower Colorado River Accounting System

A further example of GIS and RS applications in the Lower Colorado Region is their support of the Lower Colorado River Accounting System (LCRAS) program. The LCRAS program is being developed to account for water use on the lower Colorado River using a hydrologic model and acoustic velocity meter gauging systems. As implemented by the LCRAS model, cost-effective techniques using RS and GIS technologies have been used to analyze satellite data for the purpose of classifying and mapping agricultural lands, riparian communities, and open water surfaces. Results of Reclamation's satellite image analyses provide cost-effective and readily available estimates of water use which are expected to be more accurate than past assessments. The results of LCRAS and the GIS/RS inputs to the LCRAS model are now being evaluated by comparing them to the results of our traditional accounting methodology, utilizing 1995 data.

Expanded Decision-Making Process

As public interest in the operation of the Colorado River system has increased, Reclamation has paid increased attention to the process by which operational decisions are made. More open public forums have been established throughout the basin to allow interested public parties to comment on proposed decisions. These forums include both the preparation of Annual Operating Plans (AOP) for each reservoir and the upcoming review of the Operating Criteria for the Colorado River system.

Annual Operating Plans

Each of the mainstem reservoirs in the Upper Basin, along with the Lake Powell to Lake Havasu series of dams, have public meetings associated with the preparation of their AOP's. While Reclamation retains the role of the decision-maker on behalf of the Secretary of the Interior, comments received at these meetings significantly expand our understanding of public concerns.

In the case of the Upper Basin reservoirs, public meetings are usually held three or four times each year. Information is provided to attendees outlining the expected operation, particularly for the following few months when the reservoir operation is more accurately known. Research requests for specific dam releases often play an important role in determining future operations.

Review of the Operating Criteria for Colorado River System Reservoirs

The Criteria used in the operation of Colorado River reservoirs were prepared in 1970 as a result of the 1968 Colorado River Basin Project Act. Both the Act and the Criteria specify periodic reviews of the Criteria to ensure that they accurately reflect existing laws and meet the needs of the public throughout the basin.

Such a review is just now commencing. A federal register notice announcing the review has been issued and a series of public meetings will be held this year to collect public opinion regarding the criteria. Computer modeling will analyze the impacts of possible changes to the criteria and National Environmental Policy Act compliance will be conducted on any proposed action.

Increased Total Benefits From Colorado River Reservoir System Projects

As population numbers and public use of the river system increases in the West, and as habitat needs for endangered species emerge, existing water supplies are being stretched and competition for use of the water is heightened. Successful resolution will require more efficient and innovative water use arrangements, as well as continued attention to in-stream flows and riparian uses.

Water Banking and Water Marketing

Reclamation is working with the Lower Basin States and the Colorado River Indian Tribes to develop water banking and water marketing procedures to encourage extraordinary water conservation measures and to enable water to move from lower to higher valued uses. Entitlement holders who conserve and bank water may market banked water that is not needed for their future use.

Voluntary Water Transfers

Reclamation has authorized voluntary arrangements whereby entitlement holders may transfer, lease, exchange, or market water on an intrastate basis under certain conditions to promote more efficient use of Colorado River water. Discussions are under way in an attempt to identify and adopt criteria which would allow such transactions to occur on an interstate basis. Review of proposed transfers, leases, exchanges, and marketing transactions includes consideration of relevant law, potential impacts on other entitlement holders, mitigation of third-party impacts, and comments from interested parties.

As water use has increased, surplus/shortage strategies providing various levels of drought protection, in conjunction with the accompanying power pool and flood protection analyses, have been developed and provided to the entities with water entitlements. Negotiations are continuing among the water users to arrive at any mutually acceptable adjustments.

Water Conservation

Water Conservation is a key element in improving the management of Colorado River water resources. Water use applications are now more efficient and management practices have been developed to moderate growing water demands, conserve energy, improve the quality of water, and protect associated recreational and environmental benefits. The two regions have developed conservation strategies to improve the management and efficiency of surface and ground water use and increase water reclamation and reuse practices.

The Water Conservation and Advisory Centers in Salt Lake City, Utah, and Boulder City, Nevada, are the focal points of this water conservation program. The Centers are helping and/or encouraging water users to develop and implement conservation programs by providing:

- Technical assistance.
- Information dissemination and education.
- Technology development and transfer.
- Training for water system managers and operators.
- Financial partnerships.

- Improvement of Reclamation facilities.

Hydropower

The Boulder Canyon Act of 1928 set the stage for the construction of Hoover Dam and Power Plant. The original nameplate rating for the power plant was 1,340 megawatts. Beginning in 1981, and substantially complete in 1995, an uprating program for the power plant resulted in a present nameplate capacity of 2,074 megawatts, for an increase of 734 megawatts. Similar uprating programs have been performed at Flaming Gorge, Aspinall, and Glen Canyon power plants.

Summary

Reclamation has made significant progress in introducing both technical and institutional changes which have made, and are expected to continue to make, the operation of the Colorado River System more effective and efficient. These changes will facilitate the enjoyment of greater benefits from the system by its multitude of beneficiaries, both present and in the future.

Native Americans and the Colorado River

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Introduction

There are many Native American issues in the management of the Colorado River System that could be discussed, but due to the limited time and space they cannot all be dealt with here. This paper will discuss two of the more critical Native American issues and their impact on the Colorado River System. The issues to be discussed are (1) the settlement of Native American reserved water rights claims within the Colorado River System and (2) the involvement of Native Americans in the management of the Colorado River System.

Native American Reserved Water Rights Claims

Western Water Law

To fully understand the magnitude of the impact of the Native American reserved water rights claims on the Colorado River System, an understanding of Western water law is needed. Western water law began with the early miners in the West who needed water for mining operations located far from natural water sources. Diversion structures and water delivery systems were built to divert water from the streams and to deliver it to the location of the mining operation. The "first in time, first in right" use of water was looked upon with the same validity as the miners' "first in time, first in right" establishment of mining claims. The doctrine of "prior appropriation" by which Western states govern most surface water rights grew from this tradition. A state water right with a priority date is granted to appropriate surface waters with the understanding that the right provides permanent access to the water source as long as the water is put to "beneficial use" on a regular basis. The priority date determines who receives water in times of shortage, senior rights are satisfied fully before junior appropriators receive water. The prior appropriation doctrine has promoted westward expansion and development by allowing diversion of stream flows for use in economic enterprises away from the stream. This led to the full appropriation of surface water supplies in much of the arid West (Water Council, 1984) (Checchio and Colby, 1993).

Prior appropriation doctrine differs from "riparian doctrine" used in most of the Eastern states. The fundamental principle of the riparian doctrine is that the owner of land bordering a water body acquires certain rights to use the water. Each landowner bordering a water body may make reasonable use of the water on the same land if the use does not interfere with reasonable uses of other riparians. The riparian doctrine was thought to be impractical for the arid region beyond the one-hundredth meridian (a line running south through the middle of North Dakota into Texas). A system that limited rights to owners of land bordering a stream and water use to the watershed of origin would have stifled development in the West. Thus, the prior appropriation doctrine responded to early Western needs by basing water rights on the "first in time, first in right" principle. Today, water jurisdictions in America can be grouped roughly into three doctrines of water law: riparian, prior appropriation, and hybrids of the two (Getches, 1990).

In the 1800s, many Western Indian tribes gave up most of their lands and agreed to settle on reservations set aside by the U.S. government as permanent homelands for the tribal people. Unfortunately, when the Indian reservations were established, Congress did not include provisions establishing Indian water rights for the reservations. The lack of clearly-established Indian water rights led the Supreme Court in Winters versus United States to hold that when reservations were established, Congress implicitly reserved, along with the land, sufficient water to fulfill the purposes of the reservations. The Court also recognized these rights as having a priority date coinciding with the date the reservation was established. Thus, the Winters doctrine, or the Indian "reserved water rights" doctrine was born (Water Council, 1984) (Checchio and Colby, 1993).

Most Indian reservations were established prior to extensive non-Indian settlement of Western lands making the reservation's reserved water right senior in most cases. For years these senior rights have had little practical value to tribes, and unexercised reserved water rights posed little threat to existing non-Indian water uses. However, in recent years, interest in Indian reserved water rights has been on the rise. There are many reasons for this rise in interest. First, many water basins are now fully, if not overly, appropriated and the demand for water continues to increase thus making senior water rights in the basins, the most reliable water right, very valuable; second, substantive federal assistance has been made available to tribes to assert their reserved water rights claims and to develop their reserved water rights. The early priority date and the quantifying of the Indian reserved water rights has placed a cloud of uncertainty over many prior appropriation water rights previously perfected under state law.

Colorado River System

Table 1 illustrates, by state, the number of tribes, reservation acres, irrigated acres, and potential reserved water rights claims within the Colorado River System.

Table 1. Potential Indian reserved water rights claims.*

State	No. of Tribes	Reservation Acres	Presently Irrigated Acres	Potentially Irrigated Acres	Potential Water Claims Acre-Feet/year
Arizona	20	19,808,057	188,410	6,516,208	31,273,343
California	35	355,683	12,801	37,164	191,329
Colorado	2	755,400	10,200	93,000	86,390
Nevada	3	79,711	1,802	2,340	38,695
Utah	4	2,309,639	66,066	138,080	513,853
Total	64	23,308,490	279,279	6,786,792	32,103,511

* Most information comes from the Western States Water Council Report, 1984; however, some of the information was incomplete and estimates were made. The accuracy of the numbers is not crucial here because the intent is to simply show the magnitude of the number of acre-feet of water of potential Indian reserved water rights claims.

The reserved water rights claims of the tribes in the Colorado River System total an estimated 32 million acre-feet. The Colorado River System is over appropriated and as the tribes begin to assert their reserved water rights claims and develop these rights, the impacts will be felt throughout the Colorado River System. Water users' prior appropriation water rights will become so junior that they will be of little or no value. Also, the tribes could become the largest water right holders and perhaps some of the largest water brokers in the system.

Native American Involvement in the Management of the Colorado River System

In the past, Native American concerns and issues have been given limited consideration in the management of the Colorado River System and they have not had much say in the management decisions of the Colorado River System. However, in recent years the Native Americans have taken a more proactive role letting their concerns be known. Their presence in the management of the Colorado River System will be felt even more in the years to come. A good example of how the Native Americans can provide input in the management decisions of the Colorado River System is happening with the Glen Canyon Dam operations.

Glen Canyon Dam Operations

Glen Canyon Dam is located on the Colorado River about 13 miles downstream from the Utah-Arizona State line and about 15 miles upstream from Lee's Ferry. The power plant at Glen Canyon Dam has historically been used primarily for peaking power generation. The fluctuating releases associated with peaking power operations caused concern among state, federal, and tribal resource management agencies because of the impact on natural, historical and, cultural resources downstream through the Glen Canyon Recreation Area and the Grand Canyon National Park. In December 1982, Reclamation initiated the multi-agency Glen Canyon Environmental Studies (GCES) to respond to the concerns. The GCES lead to the preparation of the Operation of Glen Canyon Dam Environmental Impact Statement (EIS) filed with the Environmental Protection Agency in March 1995. The Record of Decision (ROD), to be issued by the Secretary of the Interior, is pending. Reclamation was the lead agency in preparing the EIS and cooperating agencies were federal and state agencies, and the Hopi Tribe, Hualapai Tribe, Navajo Nation, Pueblo of Zuni, San Juan Southern Paiute Tribe, and the Southern Paiute Consortium representing the Kaibab Paiute Tribe and Shivwits Paiute Tribe. (GCEIS 1995)

Representatives from the Hopi and Hualapai Tribes and the Navajo Nation served on the EIS team. The preparation of the EIS required close cooperation among the cooperating agencies, the interagency EIS team, and GCES. The road to the Final EIS was not smooth nor without many seemingly insurmountable obstacles. However, through much effort and cooperation, an EIS was produced that all cooperating agencies could abide by. The cooperating agency process has been considered a great model of how diverse interests and objectives can be brought together in a spirit of unity. The process provided a forum for the first time where the Native American's concerns and objectives on the Colorado River System were heard and responded to.

Adaptive Management. The completion of the Glen Canyon Dam EIS process will result in a decision by the Secretary on the operation of the Glen Canyon Dam . It is intended that the ROD will initiate a process of "adaptive management," whereby the effects of dam operations on downstream resources would be assessed and the results of those resource assessments will form the basis for future modifications of dam operation. Many uncertainties still exist regarding the downstream impacts of water releases from Glen Canyon Dam. The Secretary, or his designee, will develop through a group call the Adaptive Management Work Group, as appropriate, modifications to operating criteria or other management actions in consultation with interested parties. Consultation would be maintained with appropriate federal and state agencies and Havasupai, Hopi, Hualapai, and San Juan Southern Paiute Tribes, and Navajo Nation, Pueblo of Zuni, and Southern Paiute Consortium. (GCEIS 1995)

Management Responsibilities of Natural and Cultural Resources. Management objectives of Indian Tribes with interest in Glen and Grand Canyons (Havasupai, Hopi, Paiute, Hualapai, Navajo, and Zuni) are the preservation of the canyon's natural and cultural resources to maintain their values to the tribes. Many sites located on federal lands have cultural, ancestral, and spiritual significance to Native Americans and these ties must be considered in federal decision-making in the Colorado River System (GCEIS 1995).

7-10 Committee. The Colorado River System lies within the seven Western states of Wyoming, Colorado, Utah, New Mexico, Arizona, Nevada, and California. These states are referred to as the "seven basin states." Representatives of the states meet on a regular basis to discuss management of the Colorado River System. In March 1993, this working group was expanded to include representatives from ten of the tribes within the Colorado River System. The tribes are the Jicarilla Apache, Chemehuevi, Colorado River, Navajo, Cocopah, Fort Mohave, Uintah & Ouray Ute, Southern Ute, Ute

Mountain Ute, and Quechan. The current activity of the 7-10 committee is to address water shortages and distribution in the lower portions of the Colorado River System where a majority of the tribes reside. Some tribes have indicated an interest in water marketing and are evaluating their marketable resources. The committee is another example of how the Native Americans have become involved, to have their concerns and issues heard, and to provide input into the management of the Colorado River System.

Summary

The Colorado River System is the home to many Native Americans whose heritage goes back centuries before the European settlers arrived on the shores of America. The Native Americans have many natural and cultural resources that need to be managed to benefit future generations of Native Americans. The Native Americans are now, and rightly so, stepping forward and taking the reins of responsibility for their resource management. The U.S. Government, as trustee for the tribes, should support and assist the tribes as they take control of their resources and their destiny. The most important natural resource in the Colorado River System is water. The Native Americans have potential rights to millions and millions of acre-feet in the System and as they exercise these rights, the impact will be felt. As we head into the twenty-first century, the demands for water will increase dramatically in the Colorado River System. The finite amount of water available in the Colorado River System will be highly sought after and water courts could be kept very busy. Our financial resources and time should not be tied up in court battles lasting decades over water rights, but rather, working cooperatively to manage the Colorado River System to benefit all rightful water users. In order to achieve that goal, the Native Americans, having senior water rights and, collectively, being one of the largest water rights holders must become more involved in the management of the System. Their impact will be felt one way or another, why not in a spirit of cooperation where time and resources can be used effectively to benefit the most.

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The strategies and processes used by the U.S. Bureau of Reclamation (Reclamation) to meet its responsibilities in managing contemporary and future use of the Colorado River and its resources are undergoing significant change. Much of this change is tied to, and results from, changing public values and interests, as well as demands for active involvement in deciding how to manage the Colorado River. A key challenge for a water resource management agency such as Reclamation is how to balance the traditional and legally-mandated uses such as flood control, water supply, and power generation with the "nontraditional" but contemporary and growing interests in environmental, Native American, recreational, and other values and uses associated with the Colorado River.

Common themes, regardless of the process and strategies used, include a requirement for extensive and continual coordination and consultation with diverse and often competing interest groups at all levels of government and the general public; an emphasis on open, transparent public processes that use a consensus approach to problem solving; an expectation that the processes will likely result in significant increases in both time and funding to complete the necessary studies, planning and final agreements or decisions to implement actions; the importance of approaching issues in a holistic manner relative to the resources, interests and scope; and the fact that many actions will be triggered by the National Environmental Policy Act (NEPA), Endangered Species Act, or other environmental statutes or legislation.

This paper describes just two of the many examples that Reclamation uses in approaching management issues in their attempt to address the needs of various users and stakeholders in the Colorado River Basin (1) issues around the operation of the Glen Canyon Dam and (2) The Lower Colorado River Multiple Species Conservation Program.

Glen Canyon Dam Operations

The Glen Canyon Dam is an example of a project that was completed before enactment of NEPA in 1970. Beginning in the early 1980s, Reclamation began extensive scientific data gathering to begin to assess the impacts of the operation of the dam on downstream resources. On July 27, 1989, the Secretary of the Interior directed Reclamation to prepare an Environmental Impact Statement (EIS) to evaluate the operations of Glen Canyon Dam. The EIS process involved extensive public involvement activities and a complex Cooperating Agencies forum. The NEPA process extended over 6 years, culminating a in a Final EIS filed with the Environmental Protection Agency in March 1995. A requirement of the Final EIS is the use of an adaptive management process to review monitoring and research results and make recommendations to the Secretary of the Interior on operational changes at the dam. A Record of Decision is expected in late l996.

The Glen Canyon Dam was completed by Reclamation in l963 as a part of the Colorado River Storage Project (CRSP) and being pre-NEPA, no EIS was filed for its construction or operation. Likewise, the purposes under the 1968 CRSP Act were: regulating the flow of the Colorado River; controlling floods; improving navigation; providing for the storage and delivery of the waters of the Colordao River for reclamation of lands, including supplemental water supplies, and for municipal, industrial, and other beneficial purposes; improving water quality; providing for basic public outdoor recreation facilities; improving conditions for fish and wildlife, and the generation and sale of electrical power as an incidental purpose. Glen Canyon Dam preserved the possibility for the states of the Upper Colorado River Basin to utilize the apportionments made to them under the Colorado River and Upper Colorado River Basin Compacts. Under CRSP, power generation is incidental to other purposes and the powerplant at Glen Canyon Dam was primarily used for peaking power. As a result, the Colorado River below Glen Canyon Dam, which flows through the Grand Canyon, experienced daily fluctuating releases associated with peaking power operations.

Over time, other federal, state, and tribal resource management agencies, fishing and rafting interests, and environmental groups voiced concerns about the detrimental effects on downstream environmental resources. These groups expressed forceful concerns in the late l970s when Reclamation completed studies at Glen Canyon Dam to increase peaking power generation.

In l982, Reclamation initiated the multi-agency Glen Canyon Environmental Studies (GCES) to respond to these concerns and develop scientific information on the effects. The effort entailed two phases: Phase I focused on gathering initial data about the resources and was completed in l988; Phase II, initiated in mid-l988, gathered additional information on specific operation elements. In l989, in response to continued public concerns about operations at Glen Canyon Dam, the Secretary of the Interior directed Reclamation to prepare an EIS to reevaluate Glen Canyon Dam operations. The purpose was to evaluate specific options that could be implemented to minimize, consistent with law, adverse impacts on downstream environmental and cultural resources, as well as Native American interests in Glen and Grand Canyons. The GCES formed the basis for the impact assessment of the EIS and were funded from power revenues. The total cost to-date for all the studies work and preparation of the EIS documents is approximately $70 million.

Reclamation was designated the lead agency for preparing the EIS, with the Bureau of Indian Affairs, National Park Service (NPS), U.S. Fish and Wildlife Service (FWS), Western Area Power Administration (Western), Arizona Game and Fish Department (AGFD), Hopi Tribe, Hualapai Tribe, Navajo Nation, San Juan Southern Paiute Tribe, Southern Paiute Consortium, and the Zuni Pueblo serving as cooperating agencies. In addition, Reclamation, NPS, FWS, Western, U.S. Geological Survey, AGFD, Hopi and Hualapai Tribes, Navajo Nation, and a tribe consultant served on an interdisciplinary EIS team to formulate alternatives. The lead and cooperating agencies met frequently and included open meetings where interests from throughout the basin could attend and participate, and all who participated worked to gain consensus on all aspects of the EIS.

The final EIS for Operation of Glen Canyon Dam was filed in March l995 and a Record of Decision is expected in late l996. Reclamation initiated extensive public involvement during the scoping and review process by holding public meetings and distribution of newsletters. Over 17,000 written and oral comments were received during the scoping process. Reclamation later sent a newsletter with a summary of preliminary alternatives to about 20,000 addresses.

The preferred alternative selected by Reclamation and the cooperating agencies was the Modified Low Fluctuating Flow Alternative, which would restrict peak releases, limit minimum releases diurnally, and the rate of change in releases on an hourly basis. Another key component of the proposed alternative is the establishment of an adaptive management program that includes long-term monitoring and research features. The adaptive management program would allow Reclamation and other interests to obtain information that would be used to follow, evaluate, and make appropriate recommendations on the operations of Glen Canyon Dam.

The Operation of Glen Canyon Dam may appear to be normal and nothing new because it was centered around NEPA. However, NEPA is normally triggered because a federal agency is proposing a "Major Federal Action." In this case, NEPA was triggered as a result of concerns about the ongoing operational impacts to the downstream resources of the Glen Canyon Dam. Furthermore, the issues of primary concern were related to uses not traditionally at the forefront in the CRSP, (e.g., fishing, rafting, endangered species, and Native American cultural resources) but indicative of the changing demand to consider other things besides water and power uses.

Lower Colorado River Multiple Species Conservation Program

This example illustrates an approach that is primarily driven by actions under the Endangered Species Act (ESA) that apply to federal (section 7) and nonfederal (section 10) interests. Although it differs from the previous example in this respect, it is similar in demonstrating the growing influence and importance of environmental issues on current and future management of the Colorado River for traditional and legally well-grounded uses such as water supply and power generation.

The Lower Colorado River Multiple Species Conservation Program (LCRMSCP) was formally initiated in August of l995, in the Lower Colorado River Basin (Lees Ferry to the international border with Mexico) under the sponsorship of the three lower Colorado River Basin States (Basin States) of Arizona, California, and Nevada, and the Department of the Interior (DOI). The stated goals of the program are to accommodate current and future water diversions and power production on the Lower Colorado River, while working toward the recovery of endangered and threatened species, conservation of critical habitat, and reducing the likelihood of additional species being listed under the ESA.

The primary catalyst for this initiative was the listing of Critical Habitat for Big River Fishes of the Colorado River System in March of 1994. This action galvanized the water and power interests of the Basin States to seek an optimum way to become involved in current and future manage of endangered species resources in the Lower Colorado River Basin and, in particular, the impact of potential management actions on ongoing and future water and power operations. The Basin States were concerned that traditional uses might be jeopardized in favor of endangered species and wanted a place at the negotiating table. Through a contracted study, the States determined that some type of modified Habitat Conservation Plan (HCP) as provided for under section 10 of the ESA was their best approach. The States initiated dialog with the FWS and executed a Memorandum of Agreement (MOA) which established a cooperative forum and approach to discuss and plan for such matters.

The listing of critical habitat also had an immediate impact on Reclamation's operations on the Colorado River. In a separate action, Reclamation initiated informal section 7 consultation with the FWS to assess the effects of operations of the Colorado River from Hoover Dam and Lake Mead to the Southern international boundary with Mexico on critical habitat and recently-listed species. Normally, Reclamation, like most federal agencies, would prepare a Biological Assessment (BA), determine effect, and then either conclude or initiate formal consultation with the FWS. This process is federal agency to federal agency and generally limits or excludes the public unless they are an "applicant." However, given the extensive interest and desire to participate by the States and environmental groups, Reclamation decided to open its process and hold public meetings, provide periodic information updates, and invite review and comment on the draft BA.

It soon became apparent that because of the resources required to participate in both processes; scope of the effort, complexity and sensitivity of the issues, relationship of Reclamation's actions to those being considered by the States in their HCP, and the common stakeholder and interest base, that it might be more effective to combine these efforts.

After further coordination with the FWS, Reclamation decided to continue consulting informally and to put its major effort into the LCRMSCP over a 3-year period to develop (1) a long-term (50 year) conservation program for conservation of listed and sensitive (federal and state) species and their habitat while accommodating current and future operations and activities on the mainstream of the Colorado River in the lower basin and (2) identify and implement interim conservation measures that provided immediate protection and conservation for selected endangered species and associated critical habitat over this same period.

The undertaking is very significant in that it includes about 600 miles of the Colorado River in the lower basin, including developing an umbrella conservation plan (modified HCP) for about 100 species of plants and animals that occur in both aquatic and riparian habitats, involves 50-50 cost sharing of a minimum of $1.5 million a year during the 3-year program-development phase, and will provide a framework to use in completing section 7 and section 10 consultations upon completion of the LCRMSCP.

Several issues have been raised by environmental interests about this process, including whether the MOA violates the ESA by being predecisional under section 7 of the ESA; that the program subordinates species/habitat needs to the more traditional water and power uses based on order of wording in the MOA; that Reclamation is in violation of the ESA by continuing informal consultation and should enter into formal consultation because of an obvious "may effect" determination on its operations; how to identify, measure, and ensure "sufficient progress" that provides regulatory insurance under the ESA during the 3 years of program development; and that environmental interests have not been brought to the table soon enough under the States/DOI LCRMSCP concept.

These, and other issues concerning management of federal and state funding sources are currently under consideration within the LCRMSCP Steering Committee. This process, like the previous one, clearly highlights the challenges that exist because of the conflicts between traditional management emphasis on flood control, water, and power objectives and the rising demands for environmental, Native American, and recreation needs to be accommodated on the Colorado River.

Reclamation's strategies and management processes for the Colorado River Basin continue to evolve and change, but will clearly focus on actions and innovations that emphasize consensus-building, achieving balanced use of limited and competing resources, seeking and providing for open public participation, and shall include adaptive management and holistic approaches of both the watershed and resources.

Restoration On a Series of Scales: Genetic to Landscape, Local to International

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Introduction

Elwha Dam was constructed on the Elwha River, Washington from 1910-1912, 7.9 km (4.9 m) above the river mouth. It cuts off access to over 113 km (70 m) of mainstem and tributary habitat for 10 runs of anadromous fish. Despite a state law requiring fish passage at obstructions on salmon bearing streams, passage measures were not provided and salmon and trout have been restricted to the lower 7.9 km to this day. The Glines Canyon Project was built from 1925-1927 about 13 km (8 m) upstream.

Sediment has been trapped within each reservoir. Deltas, composed mostly of coarse sediment (sand, gravel and cobble), have developed at the heads of the reservoirs. The Lake Mills delta is up to 21 m (70 ft) thick (FERC 1993). Fine material (silt and clay) is more evenly distributed along the reservoir bottom, with an average thickness of 3.7 m (12 ft). Because Glines Canyon Dam blocked the flow of material, there is much less sediment trapped in Lake Aldwell. Without coarse material, the river substrate below the dams has armored, depriving fish of the gravel needed for spawning (NPS 1995).

The reservoirs store solar radiation, causing a 2-4oC (3.6-7.2oF) increase in stream temperatures below Elwha Dam in the late summer and early fall (FERC 1993). High water temperatures increase fish stress and exacerbate fish diseases; two thirds of the returning chinook salmon in 1992 died prior to spawning (DOI et al. 1994). The reservoirs also trap a portion of the nutrients and large woody debris that move downstream, reducing aquatic productivity (NPS 1995). Wildlife and the ecosystem have been impacted by the inundation of floodplain areas and the loss of nutrients that decomposing salmon carcasses provide; the ecosystem within the park has been deprived of over 800,000 pounds of carcass biomass annually (DOI et al. 1994).

In 1968 and 1973, the owner filed license applications for the Elwha and Glines Canyon projects, respectively. The Federal Energy Regulatory Commission (FERC) licensing process did not begin in earnest until the early to mid-1980s, when dam removal was proposed to mitigate the adverse impacts of the dams.

By 1991, it became obvious that years of litigation would ensue whether FERC attempted to license the dams or order their removal. The Elwha River Ecosystem and Fisheries Restoration Act (P.L. 102-495) was negotiated by Congressional staffers and signed into law by President Bush in 1992. The Elwha Act protects the interests of the dams' owner and operator, Tribe, municipal and industrial water users, and environmental groups. It also sets the standard of "full restoration of the Elwha River ecosystem and native anadromous fisheries" and gives the Secretary of the Interior the authority to acquire and remove the dams to meet this goal. The Congress maintains authority over the project through the appropriations process. Interior released a final environmental impact statement (NPS 1995) in September 1995 that recommends dam removal.

Study Area

The Elwha is the fourth largest river on the Olympic Peninsula. It is 72 km (45 m) long and drains a basin of 831 km2 (321 m2). Stream flow averages 42.7 cms (1,507 cfs) and supplies water to municipal and industrial users in Port Angeles (DOI et al. 1994). The river historically supported coho, pink, chum, sockeye and spring and summer/fall runs of chinook salmon, winter- and summer-run steelhead trout, searun cutthroat trout and char. The basin is dominated by western hemlock and Douglas fir forests, which support a wide variety of mammals, amphibians, reptiles, and birds (NPS 1995).

Elwha Dam is a concrete and earth fill structure that is approximately 32 m (105 ft) high and 137 m (450 ft) wide. It impounds 4 km (2.5 m) long Lake Aldwell. Glines Canyon Dam is a single arch concrete dam that is 64 m (210 ft) high and varies in width from 17 m (55 ft) at its base to 82 m (270 ft) at its crest (DOI et al. 1994). Glines Canyon Dam impounds 4.5 km (2.8 m) long Lake Mills. Glines Canyon Dam lies within Olympic National Park, while the Elwha Dam is downstream of the park boundary.

Dam Removal and Sediment Management

Options for removing the dams vary in river diversion methods to allow demolition in the dry. River diversion at Elwha Dam would be done by excavating a channel through bedrock underlying the north abutment and constructing a temporary coffer dam to direct the river to the channel. Following dam removal, this channel would be filled and graded to match the surrounding landscape. Demolition of Glines Canyon Dam can be accomplished without diverting the river. Gated notches would be constructed at progressively lower levels in the dam to pass the river, as layer after layer of the concrete structure is removed.

The two reservoirs contain an estimated 16 million cubic yards of sediment. Two options for sediment management have been extensively studied. The first option would allow natural erosion of the fine and coarse material, while the second would slurry much of the silt and clay to the Strait of Juan de Fuca while allowing the coarse material in the deltas to erode naturally. Only about half of the sediment would exit the reservoir areas in either case (Randle and Lyons 1995).

Natural erosion would provide the quickest physical recovery of the river, but it would result in high suspended sediment levels, impacting water users and aquatic resources. Dredging fine sediments to the Strait would minimize impacts to water quality, while erosion of the deltas would allow the bedload to replenish the lower river. Regardless, the Elwha Act requires the protection of water users prior to initiating dam removal. Protection may include new well systems, water treatment facilities, or other measures (DOI et al. 1994). Impacts to remaining anadromous fish stocks could be partially mitigated by removing fish to clean water sources (e.g., hatcheries, tributaries, the upper river) prior to and during dam removal.

Loss of the reservoirs would eliminate some resident fish and waterfowl habitat, although restoration of the ecosystem and anadromous fish would largely mitigate these losses. At least nine of the ten anadromous fish stocks affected could be restored; only sockeye salmon is in doubt because of a potential lack of broodstock (NPS 1995). Over 380,000 salmon and steelhead could be produced within 20 to 25 years (FERC 1993). Wildlife species would benefit from restoration of anadromous fish and the food these fish represent, and from recovery of 289 hectares (715 acres) of inundated terrestrial habitat (NPS 1995). Heating of reservoir waters would be eliminated, and the natural transport of sediments, nutrients, and woody debris would be restored.

Conclusions

Management reduces biodiversity through simplification and fragmentation, while human population increases diminish and degrade habitat (Winter and Hughes 1995). Through the relatively simple act of dam removal, all levels of the biodiversity hierarchy (e.g., genetic, species, ecosystem, landscape) within the Elwha basin can be restored. Deconstruction jobs and tourism would benefit the local community, monitoring ecosystem recovery would assist restoration planning nationally, and restored fish would be harvested internationally.

Restoration efforts on smaller scales may not prevent the fragmentation and loss of native ecosystems. When fully implemented, Elwha River restoration will demonstrate the capacity of a large river system and fisheries to return to natural processes on many biological and ecological levels.

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Russian River Resource Enhancement Plan

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The Russian River in Sonoma and Mendocino Counties is a typical California river system. The river basin has been developed as a water supply through the damming of the main stem and tributaries; its floodplain forests have been reclaimed for agricultural lands; its channel and its floodplains have been mined extensively for gravel; and revetment works of all varieties have been installed to stabilize the river banks. All these changes have altered the river's riparian ecosystem and its fishery. Since 1940 over forty percent of the riparian forest has been lost; the once world famous steelhead fishery of the Russian River is in severe decline. The Russian River Resource Enhancement Plan takes both a science-based approach to restoring the riparian ecosystem and a community-based planning approach to inform the public about the river and revise management practices.

Restoring the Balance

It is not possible to restore either the riparian or the aquatic ecosystem of any river without documenting long term geomorphic and hydrologic trends in the river system and formulating measures to rebalance these features. The riparian plant species which inhabit California rivers are uniquely adapted to the drought and flood cycles of the pre-development landscape. The fresh deposits of sediment left on a river bar following a flood are colonized by the pioneer plant species- willow and cottonwood. These species are adapted to withstand the mechanical effects and inundation of flood flows along the active channel. For the thousands of willow and cottonwood seedlings which germinate in such settings only a few will survive the drought of the summer. In turn as sediment is caught in these willow groves, their elevation and relationship to the active channel changes. Over the years the pioneer plants on the low elevation bar give way to higher elevation bars and eventually higher terraces with corresponding changes in plant species. The upper terrace species include oak, ash, bay laurel and others which grow where floods are less frequent and the mature stage of the habitat can develop. Through its response and adaptation to the physical dynamics of the river system, the riparian ecosystem will include a continuum of successional stages.

This complexity of plants reflects the complexity of the physical river and the pattern, density and structure in this ecosystem changes episodically as large floods and long droughts occur. The mature habitat is marked by a high diversity of over and understory plants with no single dominant species. This mature stage is occasionally scoured through channel migration and bank erosion and contributes large woody debris to the river channel. This debris is part of the complexity of aquatic habitats and important for salmon and steelhead trout. As the bank is eroded, the new sediment is sent downstream and deposits on a river bar thus starting the cycle anew. The balance in the river system between sediment supply and flood flows produce this everchanging riparian ecosystem and the many microhabitats available to wildlife.

The Russian River Enhancement Plan through extensive study of the hydrology, geomorphology, and riparian biology has documented the changes that modern development has brought to the river and the function of the riparian ecosystem. Two large reservoirs alter the hydrologic regime lowering the crest of floods but prolonging the release of floodflows long after the storm has passed. These prolonged flows saturate river banks increasing the likelihood of bank failure and adding to the instability of the system. The reservoirs are also the primary water supply for over 500,000 residents in three counties. Water is released from the reservoirs down the river channel throughout the year. Formerly the river dried up and a near surface groundwater aquifer supplied riparian forest and deep shaded pools were summer refuge to the salmon. The river now flows year round and is dominated by warm water fish species which prey on juvenile salmon and trout.

The reservoirs also significantly reduce the sediment supply in the river causing the river to cannibalize its bed and banks. Following the reduction of flood peaks through construction of the dams, farmers were encouraged to reclaim the floodplains for agricultural use. The mature riparian forest was cut down and replaced by orchards and vineyards. The river channel was narrowed and straightened and its flow velocities greatly increased. Industrial gravel mining, particularly in the Middle Reach of the river, has removed millions of tons of material from both the active channel and the floodplain terrace. The river's present sediment transport processes will not be able to replace this loss in the near future.

Further complicating any attempt to restore the Russian River are the presence of nine very large and deep gravel extraction pits along the river's edge in the Middle Reach. The bottom of these pits range from 50 to 80 feet below the thalweg (lowest point) in the river channel. Unconsolidated alluvium separates the deep pits from the river channel. This separator averages 50 to 100 feet in width and is made of the sediments that the river has been moving through the river system for many thousands of years. The pits pose a hazard in which the river channel will over time meander and migrate into these deep holes and cause massive channel downcutting and bank erosion. When this event occurs it would significantly affect agricultural land, riparian forest and river habitats and likely cause a permanent loss of aquifer storage and water supply.

The cumulative effect of these developments on the Russian River has been a change to a highly incised, downcutting river channel where riparian forest is confined to a narrow strip of the river's bed and banks. The floodplain which once supported the mature forest is now 20 to 25 feet above the active channel and is isolated from summer water levels. This now isolated, or abandoned, floodplain no longer has the physical features to reestablish riparian forest even if all current human uses were removed. The river channel is very unstable due to the imbalance between the sediment supply and the river's flood flows. Bank heights of twenty to thirty feet are common and bank erosion continues to take out the remaining mature forest. Riprap often replaces vegetation on the river banks. Increased water velocities, resulting from the narrowing and straightening of the channel, scour out pioneer seedlings. The loss of the mature riparian forest and the inability of the pioneer species to reestablish will eventually cause the loss of the riparian ecosystem along the Russian River. Under the present physical conditions no amount of planting of trees or other restoration work will be successful until the physical conditions are brought back into balance. The enhancement plan address this issue.

One of the primary features of the Russian River system that needs to be changed to achieve a more stable river system and a sustainable habitat is the allowance for an adequate meander corridor for the river. The meander corridor or the streamway must be wide enough to accommodate the natural sinuosity and amplitude of the river channel. As part of restoring the meander corridor, a new low-elevation floodplain would be created to replace the now isolated terrace area and allow for the development of riparian forest. This wider meander corridor would help slow water velocities and allow for revegetation processes to occur, as well as reduce the rate of channel incision and its negative effects on groundwater supplies and bank erosion.

In areas of the river where the floodplain is dominated by agriculture this meander corridor would represent a modest widening of the river area and would be constructed over many years as landowners experience bank problems. Particularly below the large dams, channel downcutting creates a need for continual bank repairs. These repair projects can be expensive for the farmers and future attempts to keep the river in a confined narrow channel will be less and less successful as the channel continues to incise in response to the dam's effect on sediment supply.

In the Middle Reach, the need to reduce the hazard posed by the deep gravel extraction pits could be combined with the restoration of a meander corridor and the riparian ecosystem. This alternative would require the construction of a large barrier through the pits to restrict the river from changing course into the pits. The area adjacent to the river channel would be refilled and restored to the river corridor as a low elevation floodplain. Both these concepts address the need to balance the large scale physical processes of the Russian River in order to have a sustainable riparian ecosystem.

Public Involvement

As part of carrying out the enhancement plan, the project directors convened two advisory committees, one for each of the two counties. The membership of the committee was restricted to established, incorporated groups with a direct interest in the river. A broad range of organizations were included with a special emphasis placed on including private landowners and limiting government agencies to the essential few. This decision was based on the fact that over 95% of the land in the Russian River watershed is privately owned and the plan had to address the concerns of landowners. The initial focus of the committee meetings was to establish an understanding of the science of the river including geomorphic and hydrologic elements. As we explained how the river's functions had changed, it became clear how many of the interest groups derive negative effects from the present problems. Throughout the planning process there have been lawsuits going on between members of the committee, mostly regarding the gravel mining in the Middle Reach. The project directors have had to establish ground rules and constantly focus the committee on the river rather than each other to avoid confrontation and to allow progress on the plan. After many meetings the Sonoma County committee has approved a set of alternatives which focus on the stabilization of the gravel pits and restoration of a meander corridor for the river.

Conclusion

Many of the problems on the Russian River arise from an engineering based approach to rivers which has dominated California for the past fifty years. Through the construction of dams and flood control projects our society has created a myth that we can control rivers. The enhancement plan for the Russian River addresses the need to change this myth and look for ways to restore watersheds. In contrast to the standard approach of riprapping or other means to " keep the river in its place" the plan endorses the concept of giving the river the room it needs to allow for a balance to exist in the system. The recreation of this balance, achieved on the Russian River through the creation of a meander corridor, benefits water users, farmers and the natural ecosystem as well. It will never be possible for most of California's rivers to return to their pre-settlement condition but restoring a physical balance can enhance the natural and the developed uses of the overall system.

Interagency Stream Corridor Restoration Handbook

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Introduction

The United States has approximately 3.5 million miles of rivers. The 1992 National Water Quality Inventory, required under section 305(b) of the Clean Water Act, assessed and rated water quality in 642, 881 miles of these streams. The report stated that 56% of the miles assessed fully supported multiple uses such as drinking water supply, fish and wildlife habitat, recreation, flood prevention, and erosion control. The remaining 44% were degraded by human encroachment or pollutants such as sediment, nutrients, and pesticides to the point that they are unable to support multiple uses.

Recognition of the value of stream corridors has come with the understanding of what has been lost through uninformed or misguided actions on many streams and the watersheds that nourish them. Interest in restoring stream corridors is expanding nationally and internationally, as indicated by increasing numbers of case studies, published papers, technology exchanges, research projects and symposia. Stream corridors are increasingly recognized as critical ecosystems supporting interdependent functions and values.

In November 1994, representatives of a number of Federal agencies met to discuss the need to update and improve existing guidance and manuals describing techniques for stream corridor restoration. They agreed that:

- The scientific and technical understanding of stream corridor restoration continues to grow.

- Stream corridor restoration, water quality and general ecosystem health are inextricably linked.

- Federal agencies are engaging in increasing numbers of watershed-based restoration projects, many of which involve multiple agencies and others.

- Federal agency resources can be utilized more effectively when coordinated; and

- Common scientific knowledge and technical approaches promote increased environmental effectiveness and cooperation between parties to enhance outreach and education of resource managers, private landowners, and practitioners.

With this in mind, fourteen Federal agencies, in an unprecedented cooperative effort, are now developing a handbook of stream corridor restoration planning and design technology to serve as a common reference for field level resource managers and technical specialists of the participating agencies, others and the general public.

These Federal agencies are:

- U.S.Department of Agriculture
  - Agricultural Research Service
  - Cooperative State Research, Education, and Extension Service
  - Forest Service
  - Natural Resources Conservation Service

- U.S. Environmental Protection Agency

- Tennessee Valley Authority

- Federal Emergency Management Agency

- U.S. Department of Defense
  - Army Corps of Engineers

- U.S. Department of Housing and Urban Development

- U.S. Department of Interior
  - Bureau of Land Management
  - Bureau of Reclamation
  - Fish and Wildlife Service

- National Biological Service
- National Park Service

Product and Approach

The handbook, to be entitled Stream Corridor Restoration Handbook, will offer a scientific perspective and emphasize least intrusive solutions that are ecologically derived and self sustaining. It will provide a general strategy for assessing problems; planning solutions; describing stream corridor functions, resources, and values; balancing structural and non-structural solutions; and encouraging innovation. Initial publication and distribution of the document will be sponsored through an ongoing interagency cooperative effort. The working outline for the handbook includes the following chapters plus appendices, references and a glossary:

Chapter 1: Introduction

Introduces and defines stream corridor restoration in the context of physical, chemical, and biological processes that produce stream corridor systems. Describes the national scope of the restoration technology contained in the handbook and limits its applicability to corridors associated with streams and rivers that are not typically navigable by barges. The principles and techniques are presented as applicable throughout the landscape continuum, from urban to rural.

Chapter 2: Stream Corridor Structure and Function

Lays the foundation for understanding the physical, chemical and biological characteristics of stream corridors. The interrelationships between the landscape, watershed, stream corridor, and stream reach are discussed. Introduces landscape ecology as a means to comprehend and envision stream corridors as ecosystems within the context of larger landscapes. Describes the structure and functions of stream corridors and characterizes the hydrologic, geomorphic, chemical, and biological processes that shape them. Presents associated soils, flora, fauna; the concept of disturbance in stream corridor ecosystems; and indices for evaluating quality.

Chapter 3: Planning

Offers a general planning process and common vision of project objectives and components for successful stream corridor restoration. Provides a realistic methodology for analyzing alternatives and sets the stage for practical, cost-effective restoration projects. Includes existing resource conditions, surrounding land uses, competing demands, spatial relationships, and objectives across a range of scales as prerequisites of effective planning.

Chapter 4: Design

Focuses on the selection and design of appropriate stream corridor characteristics. Geomorphic and hydrologic analyses are used to assess stream stability. Reviews soil bioengineering, riparian restoration, land management practices, and other methods to promote streambank, floodplain, and upland stability. Offers informal design, desktop design and modeling as three increasingly complex design approaches. Describes levels of restoration effort ranging from simply eliminating the cause(s) of stream impairment and waiting for the natural healing processes to work, to extensive restoration work including channel reconstruction and revegetation.

Chapter 5: Implementation

Describes the resources and sequence of activities that are necessary to successfully construct restoration practices and systems. Discusses division of responsibilities, construction planning_natural system requirements, construction planning_logistics, site preparation, site construction, labor and resource costs, and characteristics common to every successful restoration project.

Chapter 6: Performance Evaluation

Provides a general approach for monitoring whether the restoration project is achieving the specific goals identified during planning. Offers a conceptual framework for evaluating restoration and reporting lessons learned, including monitoring techniques.

Chapter 7: Maintenance and Management

Discusses adaptive management and maintenance to achieve project longevity. Describes special urban and rural considerations, including measures to protect restored areas.

Conclusion

The participating agencies are dedicated to improving the science and application of stream corridor restoration technology and transferring the related techniques and approaches to all interested parties. Cooperative development of this handbook will enhance and encourage the sharing of expertise, resources, and facilities; make more efficient use of funds; and provide consistent information on stream corridor restoration. In addition, a cooperative effort will increase the availability of information to those restoring stream corridors and to the public in general. The handbook is scheduled to be published and distributed early in 1997.

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Reservoir Watershed Protection: Staff and Curriculum Development for Drinking Water Source Protection_A Collaborative Environmental Education Project

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This paper describes a collaborative environmental education project by Baltimore and Carroll Public Schools, the Reservoir Watershed Protection Program for metropolitan Baltimore, and the Baltimore Metropolitan Council. Its goals are to develop a reservoir watershed protection curriculum that meets state and county educational outcomes, train a corps of teachers in both school systems in its use, encourage a sense of environmental stewardship for the watersheds by students, and use the curriculum in middle and/or high schools in Baltimore and Carroll Counties, Maryland.

Reservoir Watersheds

Water from three large reservoirs_Loch Raven, Prettyboy, and Liberty_is the primary source of drinking water for over 1.6 million customers in Baltimore City, and Anne Arundel, Baltimore, Carroll, Harford, and Howard Counties. Baltimore City owns the reservoirs and treatment systems and is responsible for the quality of water delivered to customers. Reservoir watersheds span large portions of Baltimore and Carroll Counties. Loch Raven, a 23-billion-gallon reservoir north of Towson, Maryland, has a 223-square-mile drainage area mostly within Baltimore County, but also in a large area in northeastern Carroll County. (See Figure 1.) Prettyboy, a 20-billion-gallon upstream reservoir in northern Baltimore County, drains an 80-square-mile area in both Baltimore and Carroll Counties. Liberty, a 43-billion-gallon reservoir along the boundary between Baltimore and Carroll Counties, drains a 164-square-mile area mostly in Carroll County, but also in a large portion of Baltimore County.

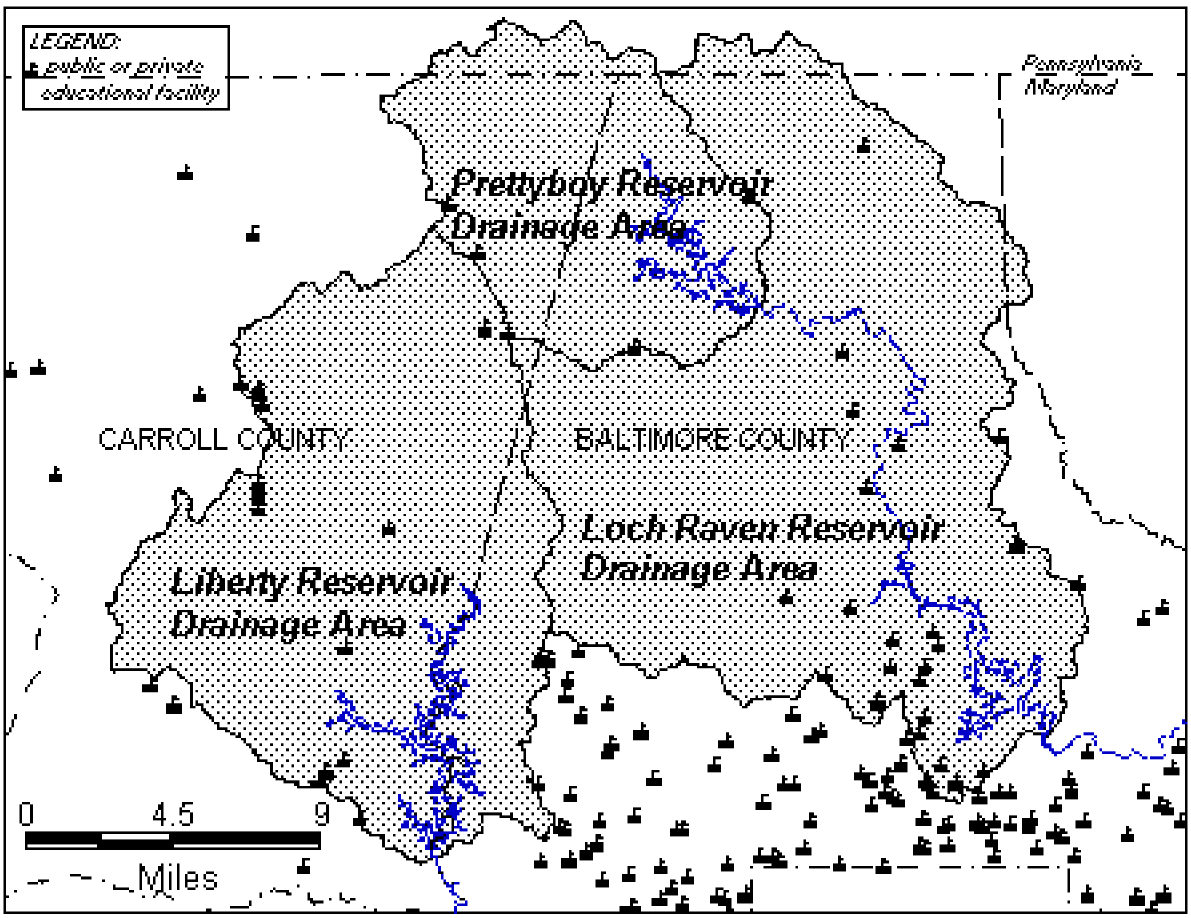

Figure 1. Public and Private Educational Facilities and Reservoir Watersheds.

All three reservoirs were found in the early 1970s to be in various states of eutrophication. Phosphorus from sewage treatment plants, agriculture, and urban development was causing excessive growth of algae. Algal blooms were causing problems in the water supply treatment plant and were adversely affecting the taste and odor of drinking water. These concerns led to the Reservoir Watershed Management Agreement among Baltimore City, Baltimore and Carroll Counties, the Maryland Departments of Agriculture and the Environment, the Baltimore Metropolitan Council, and Soil Conservation Districts in the watersheds. The Agreement put in place a Reservoir Watershed Protection Program and an Action Strategy. There has been much progress in controlling point sources of pollution in the watersheds. While measures to control nonpoint pollution have also been implemented, concern has grown over the diffuse nature and sources of these nonpoint pollutants. A key action item in the Protection Strategy is to increase public awareness and to motivate people to practice pollution prevention.

Approximately 60,000 households live within the watersheds. Over 120,000 students attend public schools in Baltimore and Carroll Counties. Virtually all homes within Baltimore County's Metropolitan District receive treated public drinking water from the reservoirs. Liberty Reservoir water is used in southeastern Carroll County. Many students both live and attend schools located in the watersheds. Other students live in the watersheds but attend schools outside the watersheds. Others attend schools in the watersheds though they live elsewhere. Public school curricula apply throughout each county. The Reservoir Watershed Protection curriculum is used throughout each county.

An Environmental Education Partnership

This project is an environmental education partnership of Baltimore County Public Schools, Carroll County Public Schools, the Reservoir Watershed Protection Program, and the Baltimore Metropolitan Council. We are grateful for funding assistance provided by EPA's Environmental Education Program, and for supplemental funding by the Chesapeake Bay Trust for equipment needed to implement the monitoring and research component of this project. Our curriculum draws upon the volunteer stream monitoring program of Maryland Save Our Streams (SOS).

The project was closely related to parallel public awareness efforts sponsored by the Reservoir Watershed Protection Program and recommended in the Public Awareness Marketing Plan for the Reservoir Watershed Protection Program prepared by SOS under contract with the Baltimore Metropolitan Council. In collaboration with SOS, a series of reservoir watershed protection workshops was offered for the general public. Workshops featured displays, resource materials including a reservoir watershed "personal action plan" brochure, and presentations by participating organizations. Another important part of the public awareness effort was a survey of households in the watersheds done by the Schaefer Center for Public Policy. The results of the survey assisted the environmental education project in determining watershed residents' awareness of the reservoir watersheds and their perception of the quality of the water in lakes and streams in their communities. The survey revealed significant gaps in public knowledge and information. Several years from now a post-campaign survey will be taken to help evaluate the effectiveness of the campaign and offer further insights as to curriculum development needs.

Baltimore and Carroll County Public Schools have excellent environmental education programs. Student exposure to the ecology of lakes and reservoirs, watersheds, and knowledge and appreciation of where drinking water comes from was limited, however. This project enabled Baltimore and Carroll County Public Schools to fill this gap and to enhance environmental educational teachers' skills through workshops and curriculum development. The project also increased state and local government capacity to deliver environmental education. It established a new environmental partnership.

This is a two-year effort. During the first year, a team of six (6) environmental educators from the two school systems was selected along with an enviornmental education consultant. In an intensive week-long summer workshop they reviewed current K-12 environmental education curricula, and enhanced it by adding components that address reservoir/lake ecology, watersheds, public water supplies, and reservoir protection. The curriculum they developed was comprehensive. It integrated knowledge of reservoirs and watersheds with environmental science, social science and community issues, and personal stewardship. In addition to classroom teaching activities, the curriculum includes field trips to reservoir sites for personal study, research and observation. The new curriculum components were field tested during the following school year in the six home schools of the environmental educators. After applying the program in their own schools, the team met during the following summer to evaluate experiences, reshape outcomes and modify curriculum components as necessary and appropriate. This summer workshop also included staff development for additional teachers. The "teacher-trainers" have become resource persons and trainers of educators throughout the school systems.

The Reservoir Technical Group of water quality staff from organizations participating in the Reservoir Watershed Protection Program met with the teachers and consultant. They provided resource materials and special insights about water quality management programs in the watersheds served by the school districts. A meeting of the Reservoir Technical Group with local government staff responsible for public outreach helped coordinate this effort with those of other organizations.

Results

The existing outstanding environmental education programs in these two school systems assured a successful outcome for this project. Experienced and motivated teachers and administrative personnel were selected by the county science supervisors. The size of these two school systems made the per-student cost of developing the curriculum very low. This project has closed gaps in the current environmental education programs in Baltimore and Carroll Counties by improving teaching skills. It increased the capacity of state, regional and local organizations to help develop and deliver environmental education in a collaborative style. It facilitated a partnership among the two local school systems, participating organizations in the Reservoir Watershed Protection Program, and the Baltimore Metropolitan Council.

Local governments and other governmental organizations participating in the project have learned more about environmental education in the two school systems. Through this project they have had an opportunity to suggest points for inclusion in environmental education curricula relating to reservoir watershed protection. This project offers an excellent model for building governmental capacity to deliver environmental education. The audience reached by this project includes public school environmental educators and their students in Baltimore and Carroll Counties. Because a student is part of a household, other family members have become aware of these issues.

As a result of this project, a corps of "teacher-trainers" skilled in teaching about reservoirs, drinking water supplies and watersheds are available as resource persons and staff development specialists. Each teacher is adapting the curriculum guides in unique and creative ways, ranging from classroom models to a comprehensive interdisciplinary focus on reservoir streams and watersheds involving student "service hours" for participating students. Students are gaining an appreciation of these issues through hands-on experiences at the reservoirs, critical thinking, and problem-solving skill development. The reservoir watersheds are providing a living laboratory for students and teachers in their home communities.

Self-evaluation is an important part of this project. Key criteria used to evaluate the project include: Do students gain an understanding of the ecology of lakes/reservoirs and their watersheds? Do students gain an understanding of public water supply systems? Do students become more aware of the linkages between what they do in their everyday lives and the quality of the waters that feed into our sources of public drinking water? The inclusion of reservoir watershed protection and related science and stewardship in the ongoing environmental education programs of Baltimore County Public Schools and Carroll County Public Schools has been accomplished.

Tips for Other Organizations Considering Similar Environmental Educational Efforts

Start your process by contacting the science advisors in your school districts. They know their current curricula and the state's environmental educational requirements. They know about funding for environmental education. And they know the teachers within their areas of responsibility. Also contact the environmental education coordinator at the state department of education. He or she can fill you in on relevant statewide programs and offer some good advice. Form alliances with other organizations seeking similar goals, especially the source water protection program in your community. They know the importance of public awareness and education in preventing pollution within watersheds. Don't try to reinvent the wheel! Take advantage of the rich body of environmental educational materials that is already available. While these materials can save you time and energy, they are no substitute for specifically designed curriculum guides that focus on specific resources and suggest site-specific field activities. Include field experiences for students. And finally, play a supportive role for teachers and administrators by providing resources, contacts, and encouragement.

Watershed Education and Watershed Management: Using the River as an Interdisciplinary Teaching Tool

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Introduction

Aldo Leopold once wrote: "A river is its watershed". Those words ring even more true today as watershed management is moving from the end-of-pipe solutions that so often characterized point source problems to remedies and strategies designed to reduce nonpoint source pollution. Erosion and sedimentation, persistent toxic contamination, and polluted stormwater runoff are the problems of the day. These problems, and their potential solutions, require a greater degree of institutional cooperation than ever before, and a high degree of public understanding and support. To significantly reduce polluted stormwater runoff, for example, requires an active change in the way people conduct their daily lives. This kind of shift in thinking requires education about issues, but also a sense of concern for the river. The intent of this paper is to describe the Rouge Education Project (REP), a school-based watershed education program in Detroit and its relationship to the Rouge River National Wet Weather Demonstration Project. The authors' contend that the solution to these more diffuse watershed problems rests heavily on public participation and public support-a school-based watershed education program is a very effective approach.

Historical Setting

Abandoned automobiles, discarded shopping carts, eroded river banks, raw sewage, and toxic-laden sediments defined the Rouge River in 1985. It was in this year that the International Joint Commission designated the Rouge River an Area of Concern. One of 42 Areas of Concern around the Great Lakes Basin at that time. This designation led to the development of a cleanup plan, or Remedial Action Plan (RAP) to restore beneficial uses to the Rouge River.

Remedial Action Plans follow three stages: (1) problem identification and description of causes, (2) identification and implementation of remedial actions, and (3) evaluation of remedial actions and restoration of beneficial uses. Throughout this process, public involvement and education were recognized as essential to the future success and sustainability of remedial efforts. This recognition led to the birth of Friends of the Rouge in 1986, a nonprofit group committed to the restoration and stewardship of the Rouge River. Friends of the Rouge has become a driving force for public participation and education within the Rouge River watershed through two major efforts: Rouge Rescue, a river clean-up and restoration effort that attracts more than 2,500 volunteers annually, and the Rouge Education Project.

The Rouge Education Project

The REP is a school-based watershed education program. The goal of the Rouge River Education Project is to develop a citizenry in the Rouge River basin that is aware and concerned about the river. To accomplish this goal, several objectives need to be met.

- To link diverse schools and communities together-rural, suburban, and city through the common thread of the Rouge River.
- To provide a watershed focus and watershed-wide analysis.
- To increase student problem-solving skills.
- To encourage an interdisciplinary focus (science, language arts, mathematics, visual arts, social studies).
- To promote student empowerment and action-taking.

The educational model fostered by the REP focuses strongly on the watershed as a hydrologic feature, but also as a teaching tool. Schools sample from many different points along the watershed, and share information and water quality data through a computer network. This network provides to students (and by extension their families) a picture of water quality throughout the watershed. Where are the problem areas, and why? What is upstream from my site? What is downstream from my site? Where is water quality good and why? The why, what, and where questions lead students and teachers to potential sources of pollution, or of protection. They also lead schools to community people who may have answers; these could be agency people, business people, or university people. The foundation of the REP is this network, both among schools and as schools reaching out to their communities.

Watersheds are inherently interdisciplinary-they are crucibles of human activity. Social, economic, and political concerns are played out in land use decisions, and in decisions that affect water quality and quantity. When students and teachers begin to look at watersheds in this way they are taking an ecosystem approach which is the backbone of the RAP process. Watershed related problems: polluted stormwater runoff, combined sewer overflows, and toxic contamination of sediments require effective problem solvers who combine a technical understanding of the problem with the skills to work effectively with others. In order to build an effective citizenry in the Rouge watershed, these understandings and skills need to be nurtured.

Watershed Education

This year, at least 100 schools (K-12), nearly 200 teachers, and over 9,000 students will participate in the REP. But what does participation mean? For elementary students and their teachers it means measuring dissolved oxygen, BOD, temperature, turbidity, and pH; collecting and indexing benthic macroinvertebrates; and, conducting aesthetic surveys of the river. For middle school and high school students and teachers participation means measuring nine water quality tests that make up the National Sanitation Foundation's Water Quality Index (NSF, WQI): dissolved oxygen, fecal coliform (and e-coli) bacteria, pH, BOD, Temperature, Nitrates-Nitrogen, Total Phosphorus, Turbidity, and Total Solids (Mitchell and Stapp, 1996). In addition, these grades also sample for benthic macroinvertebrates and apply diversity and tolerance indices. Aesthetic surveys are part of all grades. See Figure 1 for an example of the sequence of science activities from elementary through high school.

Grades	
9-12	**aesthetic monitoring * macroinvertebrate sampling/indices * topographic maps, aerial photos, satellite images * GIS, ArcView * NFS, WQI * stream velocity and discharge**
	▲
6-8	**aesthetic monitoring * macroinvertebrate sampling/indices * topographic maps/aeril photos * NSF,WQI * stream velocity and discharge**
	▲
K-5	**aesthetic monitoring * macroinvertebrate sampling/indices * dissolved oxygen, pH, BOD-5,temperature, turbidity * stream velocity**

Figure 1. Sequence of science activities in the REP, elementary through high school.

Although the core monitoring program occurs in May, teacher and student training occurs throughout the school year. Education staff and experienced teachers lead computer networking workshops, a GIS/remote sensing workshop, a bus tour of part of the watershed, and water quality monitoring workshops. Along with teacher training, classes are held at local universities to train students to become resource assistants to new teachers to the program. These trained university students work for two weeks every day at schools during the core monitoring effort.

The culmination of the REP each year is the Rouge Student Congress. Student representatives from participating schools and their teachers come to exhibit their art work, displays, or projects; share water quality data; and, perform songs or theater. It is a significant forum for bringing schools together with decision-makers. The Student Congress also is a way to highlight connection to the larger Rouge River National Wet Weather Demonstration Project.

The Rouge River National Wet Weather Demonstration Project

In 1992, Wayne County received a large EPA demonstration grant to study the impact of wet weather flows on water quality, to design alternative methods of removing contaminants from stormwater, and to evaluate the most efficient suite of methods for control of wet weather pollution. There are nine program elements: GIS development, data collection and field work, water quality sampling, computer modeling, nonpoint source BMP's, combined sewer overflow evaluation, financial/institutional analysis, and public involvement and education. Since 1992, the Rouge Education Project has been funded through the Demonstration Project under Public Involvement and Education.

Currently, the Demonstration Project is in the implementation phase. There are 17 major construction projects underway in the watershed including the: construction of huge retention/treatment basins, separation of combined sewers, and development of wetlands to store and treat stormwater. Evaluation of the effectiveness of these remedies is a next major step in the process. The focus increasingly is on specific projects at the community or sub-watershed level. Within communities, significant improvements to stormwater quality can be made over time through the combined efforts of thousands of individuals. Such improvements flow from an educated and concerned public.

How do you build a critical mass of people who will continue to push for improvements in water quality? How do you change the way that people interact with their environment-to become more environmentally responsible? How do you avert future water quality problems long after these large projects have left the scene? Answers to these questions lie in a comprehensive education program aimed at both schools and communities. The Rouge Education Project provides a strong foundation upon which to build adult and community educational initiatives.

The Friends of the Rouge and the Demonstration Project are working together on several projects that will build sustainability. Students and community citizens will soon play a greater role in data collection through adoption of aesthetic monitoring and through broader use of the NSF, WQI. This data collection serves two purposes: it gets people involved and it generates data that can reveal long-term trends in water quality. Selected schools in the REP will be working more closely with their communities through a GIS program using ArcView 2.1 to study land use in communities and to help in local planning efforts. They are also participating in an Adopt-a-Stream Project in which community groups monitor the river, undertake stream restoration projects, and improve wildlife habitat.

What Have We Learned About Watershed Education?

School-based watershed education programs must coexist within two worlds: the world of education and the institutional structure of schools, and the world of community in which most of the activity occurs. The constraints posed by schools sometimes conflict with the needs of the broader community. For example, student monitoring would be most helpful to the community if it were conducted at least monthly, but because of financial constraints in schools and an overflowing curriculum, schools are fortunate to sample twice a year.

- It is essential to foster administrative and school district support for the project from the beginning.

Sustainability is a popular word these days. In the context of school-based education programs it means institutionalization of student watershed education within the curriculum, but it also means building partnerships in the community and generating a stable, local funding base.

- Work with curriculum coordinators and educational initiatives to build credibility for watershed education programs and infusion of these programs within the curriculum.

- Build partnerships with community groups and institutions that can help enrich the program (Figure 2).

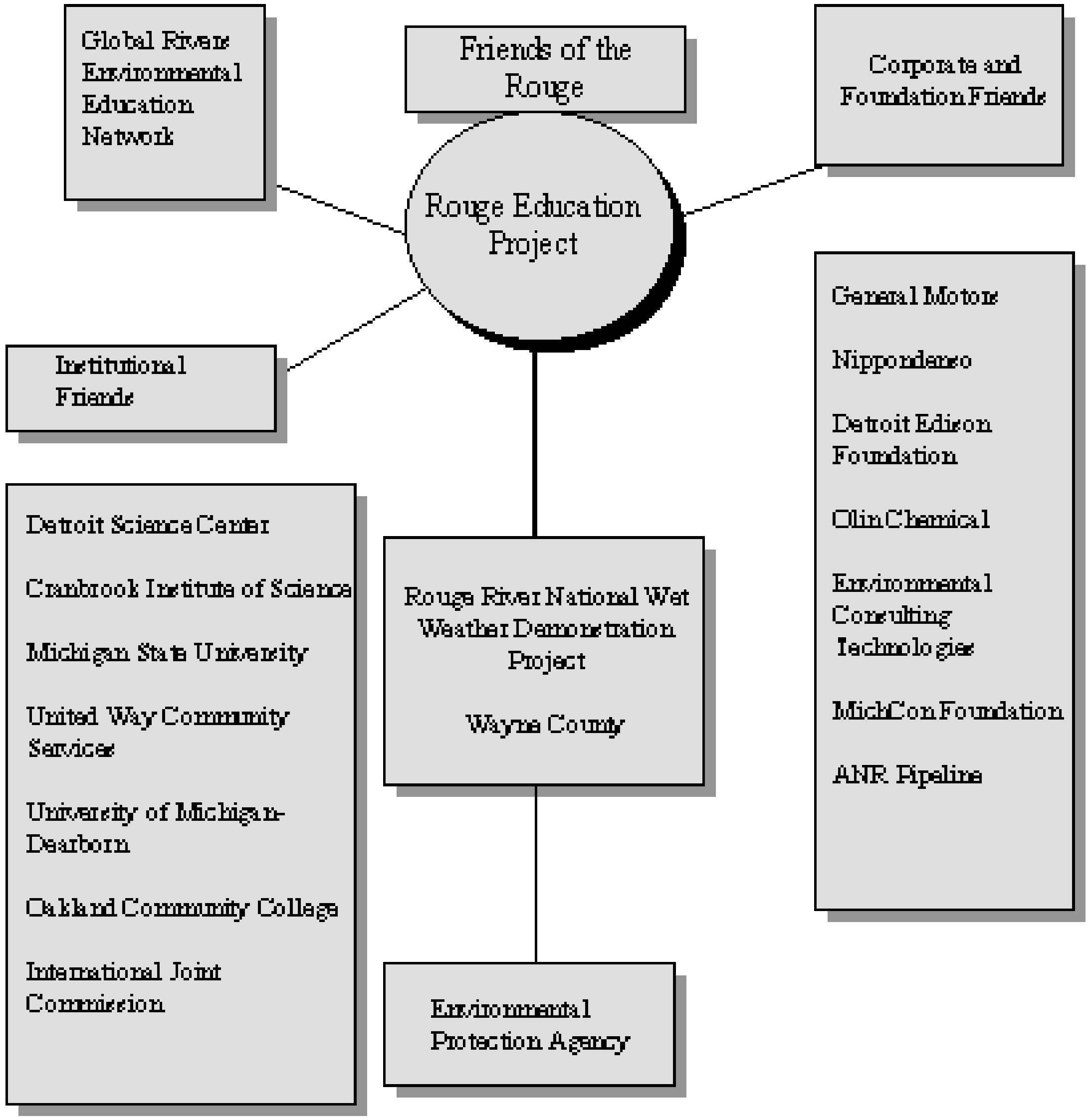

Figure 2. The Rouge Education Project and its Friends

How do we know we are meeting our objectives? Are we enhancing problem solving skills? Are we contributing to increased understanding of the watershed? These are questions tied to both program assessment (how are we doing as a program) and to educational assessment (are students meeting educational objectives related to this program?)

- Build systemic forms of assessment into the program-both program assessment and educational assessment.
- Align the activities and curriculum of the program with state and district educational objectives.
- Work with scientists, agency people, and communities to design the program to meet some of their monitoring needs.

Are there forms of monitoring that schools could realistically undertake that would contribute to the broader data collection efforts of watershed management? What water quality information is lacking, or that cannot be collected by underfunded state agencies?

- Seek to collaborate with watershed management groups by contributing to gaps in understanding of the watershed.

These lessons can be put to work to build viable watershed education programs that will help make possible the ambitious goals of watershed management programs. A river and its watershed are too complex and diverse for any one group or agency to effectively manage; it takes all of us. School-based watershed education programs have effectively worked to build broad public support and active participation to restore and protect watersheds throughout the United States.

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Plugging People Into The Watershed Team Approach: The Community Watershed Project

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Scenario: a citizen notices that the stream that flows through the neighborhood is chronically clogged with trash, has loads of sediment in it, or has an oily sheen, and wants to "do something" to help the stream. The citizen calls a local or state environmental office, offering assistance, and is told "urban streams are just like that" or "go pick up the trash." Discouraged, the citizen is led to believe that there is little that can be done, and she or he must be the only one concerned about the stream.

The lost energies of these citizens are a great opportunity cost for the health of our streams. Many of the people who receive these types of calls routinely have longed for a way to "plug" people in_to make use of their concern and energy in a constructive way. But where and how do we plug them in?

The Environmental Education Center at Miller School (EEC) has teamed with local government agencies in the Charlottesville/Albemarle County region of Virginia to create a framework of Watershed Teams, known as the Community Watershed Project (CWP). The CWP was initiated as part of an EPA section 319 nonpoint source grant.

The unique characteristics of the watershed teams include the following:

- Each team focuses intensely on a local watershed (several square miles) where actions can be directed and results accomplished.

- Schools function as the hub of each watershed team. Each participating school has a liaison to the project and equipment, such as storm drain stencils and kick-seine nets.

- Interested citizens can plug in through their local school to participate in stream monitoring and other watershed activities. Neighborhood associations are also being encouraged to "plug in."

- Computer technology is being adapted for the project; watershed teams will soon be sharing stream data on the Internet.

The various components of the Community Watershed Project are outlined below.

Community Watershed Map

The first step in actualizing the watershed team approach was to identify individual watersheds that made sense from an organizing and management standpoint. These watersheds could not be too big so that organizing became cumbersome, or too small so as to lack critical mass. The City of Charlottesville and Albemarle County were mapped into thirty-one "home watersheds" assumed to be of appropriate size. All schools in the region were added to the map to conceptualize the potential for school-based watershed teams.

Teacher Workshops

During 1994 and 1995, teacher workshops were held to initiate the project by training teachers in stream monitoring, storm drain stenciling, watershed mapping, and other skills. Teachers attending the workshops represented about half of the thirty-one home watersheds. The teachers divided into watershed groups and began the process of developing watershed-based action plans. The watersheds represent vastly different land uses, from ultra-urban to rural, and team efforts must reflect these varying watershed realities.

Recent workshops built upon this foundation by providing teachers with practical guidelines for designing projects to improve water quality on and near their school property, and by introducing supporting curricula, such as Project Wet.

Student Water Congress

Now that many teachers have been trained through the CWP and conducted activities in their classrooms, it is time to draw together the students that form the core of the newly-assembled watershed teams. This will be accomplished through a Student Water Congress. The Congress will involve middle and high school students from across the Thomas Jefferson Soil and Water Conservation District (TJSWCD) on

Earth Day, 1996, in conjunction with the District's Envirothon Competition. Delegates will prepare for the Congress by identifying and researching issues that affect water quality in the watersheds right where they live and go to school.

The Student Water Congress is a critical stage in the development of the EEC's Community Watershed Project. Now that the framework for the Community Watershed Project has been established, it is time to systematically build each watershed-based, school-led team so that it can begin to function as a self-supporting unit. The Student Water Congress, along with associated preparation and follow-up activities, will help build this watershed team structure and also provide a mechanism for connecting each team to the others throughout the TJSWCD. By focusing education and restoration projects on each particular watershed, students and fellow watershed residents can pursue the enormous task of restoring the Chesapeake Bay at a scale where they can make a difference and document results.

On the day of the Student Water Congress, delegates will make presentations about their home watershed, including the following:

- A map showing the home watershed location in relation to other community watersheds.
- How upper watersheds affect downstream water resources.
- Current water quality of their streams as determined through SOS monitoring and research of existing data.
- Stream discharge.
- Recreational uses of their streams, including fishing, boating, swimming or simply kids playing in the creek.
- Land uses in the watershed and proposed land use changes.
- Ideas for action projects, such as streambank stabilization, clean-ups, and BMP implementation.
- Current and potential stewardship partners (each team is asked to bring a community member).
- Decisionmakers and agencies that affect water quality and habitat.
- Oral histories from long-time residents.
- Suggestions for a region-wide theme or project to be taken back to each home watershed for local implementation.

- A logo design for the home watershed that can be placed on t-shirts, publicity, bridges, and storm drains.

The Student Water Congress provides a mechanism for students and citizens to address the Chesapeake Bay right where they live. Although the entire soil and water conservation district comprises only a few percent of the Chesapeake watershed, and the dozens of subwatersheds identified within the district are fractions of that percentage, the power of a local, watershed-based, school-led approach to restoring the Bay is that it breaks down the task to a point where it can actually be accomplished. A successful Student Water Congress is the beginning to ultimately engaging neighborhood associations, businesses, civic groups, government leaders and all other community structures in the Community Watershed Project.

World-Wide Web Stream Study Unit

EEC staff worked with the University of Virginia faculty and students to develop a web-based stream study designed to prepare students for macroinvertebrate (SOS) sampling in the field. The computer network provides a technological component to our CWP by making it possible for watershed teams to create home pages about their watershed and school and to share data on the web with other teams.

Kellytown Habitat Project

The CWP took on a new hue with the Kellytown Habitat Project, which is a collaborative effort between the EEC, the City, a neighborhood association, the University of Virginia School of Architecture, a local developer, and technical people from various agencies. This team is developing a highly participatory process whereby a land development project will incorporate a habitat area along a stream and innovative design features to enhance the habitat and water quality.

The stream that runs through the project site, Kelly's Creek, provides a physical connection between our CWP and habitat protection projects, and has been a focal point for student interest from nearby schools. Our approach is to use the CWP home watershed map as a framework for spinoff projects, such as habitat protection. Watershed teams that monitor and identify with particular streams can also apply their energy and expertise to other environmental considerations, such as habitat protection, within the natural boundaries defined by the watershed.

Can the Community Watershed Project Succeed?

Teachers and others in the community have responded quite favorably to a watershed approach that minimizes the importance of such matters as what school system one belongs to. Neighborhood associations have also expressed keen interest in the project.

A chief obstacle to full implementation of the CWP is the enormity of work associated with creating a totally new way of organizing people and their environmental interest. We are finding that each individual team needs some prodding and follow-up to make the watershed glue stick. In general, people are not accustomed to identifying with a watershed as they would with a neighborhood, jurisdiction, or other type of community. However, when the rain falls, the "members" of a watershed are tied together. whether they recognize that fact or not.

Also, it is difficult to secure the funding necessary to meet the community's interest that is just sitting there waiting to be tapped. When funding is spread over the entire watershed network, it is used to organize and build the CWP framework, but this does not guarantee the permanence of each team. Funding is needed at the micro-level, at least initially, but is hard to obtain from outside sources because of the small-scale nature of the projects.

Visions of the Community Watershed Project

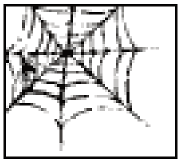
Given the obstacles outlined above, we remain sanguine about the potential inherent in the Community Watershed Project. Public and private agencies have converged on this theme of watershed teams and local action. In order to succeed, we must remain focused on and be guided by our visions for the project. These include:

- Well-organized watershed-based teams will serve as stewards of the total environment in each watershed.

- The natural linkage between small-scale watershed teams will create the means for watershed protection on an increasingly larger scale, until resources the size of the Chesapeake Bay can be addressed realistically.

- The reorganization of a community's approach to its environment based on natural, rather than arbitrary political boundaries, will lead to comprehensive solutions that involve people from all sectors of the community.

- The energies and talents of interested individuals and organizations will be effectively "plugged-in" to an ongoing and ever-expanding network of watershed teams.



CREEC: A Central Oregon Partnership Focused on Watershed Education and Restoration

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Introduction

The acronym CREEC stands for Crooked River Ecosystem Education Council. CREEC is a watershed restoration and education partnership located in the Crooked River watershed, a tributary to the Deschutes River in Central Oregon. Major partners in this effort include; the Crook County School District (CCSD), the Ochoco National Forest (USFS), the Oregon Department of Fish and Wildlife (ODFW), the Ochoco Chapter of Trout Unlimited (TU), the Prineville District of the Bureau of Land Management (BLM), and the Oregon Water Resources Department. Many other partners have also played significant roles in individual activities. CREEC's Mission Statement is:

> "Provide watershed-based educational curriculum for the Crook County School District that covers classroom lessons, field studies and work experience environments for all students as well as yearly, renewable watershed rehabilitation projects designed to enhance the Crooked River Basin and increase public awareness of the watershed's importance."

Although restoration of the Crooked River watershed is clearly one of the primary goals of CREEC, this paper will focus solely on the educational goals of the partnership. The Crooked River watershed is located near the geographic center of Oregon. Prineville is the population center and county seat. Primary industries include ranching and wood products manufacturing. As with many other areas in the rural west, water quality and fisheries habitat have declined in the Crooked River basin in the past 150 years. Dams, road building, logging, livestock grazing, uncontrolled recreational use and irrigation have been the primary causal agents in this decline. As a result, streams that used to be major producers of anadromous fish such as spring chinook salmon and summer steelhead now contain only non-game fish or introduced warm water species such as smallmouth bass. Populations of redband rainbow trout (Oncorynchus mykiss), the primary native coldwater gamefish in the basin, are fragmented and restricted to headwater areas where relatively good habitat conditions remain.

The central idea for CREEC began to take shape in 1989. That year, concern over watershed conditions and the status of the fishery resource led several local people to form the Ochoco Chapter of Trout Unlimited. In 1991, as part of a Statewide series sponsored by the Oregon Rivers Council, a Crooked River Watershed symposium was held in Prineville. Although there was little agreement among the disparate groups that attended the symposium, this event was a milestone because it was the first-ever attempt at bringing together all of the entities and individuals that had a stake in management of the watershed.

Also in 1991, TU chapter members began working with local teachers and agencies towards the goal of educating students about watershed conditions and processes. In 1992, members wrote their first grant to the Governors Watershed Enhancement Board (GWEB) to obtain funds to begin implementing a watershed curriculum in local schools. The grant was denied due to what GWEB perceived as a lack of local support for the program. In May of 1992 Trout Unlimited, in cooperation with the USFS and BLM, arranged a tour of the watershed for the National Fish and Wildlife Foundation (NFWF). The Foundation is based in Washington DC and matches federal money to private donations through a program called "Bring Back the Natives". As a result of this tour, the Chapter got its first grant for what was to later be known as CREEC. This grant money went to the Crook County School District to help fund a greenhouse on school grounds with the understanding that some of the space in the greenhouse would be used to cultivate native riparian plants that would eventually be outplanted back into the watershed at restoration sites. This was a significant step for the partnership. By being able to present a check for $5,000 to the school for educational purposes, the program attained legitimacy in the eyes of the school board and community. Since that time the partnership has grown substantially. The annual budget for CREEC has averaged between $60,000 and $120,000 for the past three years. This money is obtained through agency contributions, NFWF matching funds, grants and donations. The program reaches approximately 2,000 students per year annually in a county whose total population is 14,500 people.

A second fortuitous circumstance that helped CREEC gain momentum was the passage of the Oregon 21st Century Education Act. This landmark legislation radically altered the way the public school system in Oregon was to be operated. Key aspects of the Act included more emphasis on developing partnerships between school districts and local agencies and business, as well as development of curricula for at least six broad occupational categories that students could choose to pursue to achieve the Certificate of Advanced Mastery needed to graduate. One of the six occupational categories identified in the Act is Natural Resources. As an existing partnership with a focus towards watershed management, CREEC was ideally positioned to help the Crook County School District meet the requirements of this new legislation.

From the outset CREEC was proposed as a long-term effort with a minimum lifespan of ten years. Over the past three years the partnership has evolved from a loosely organized collection of agency and volunteer group representatives to a more formal organization with a coordinator and both educational and technical committees. Meetings are held monthly with attendance by representatives of member agencies, groups, teachers and students. Notes of the meetings are kept and distributed to members. Meetings are a combination of general information sharing and business. Decisions are made on such items as; buying equipment, teacher inservice, curriculum development and funding of educational efforts such as sponsoring field trips, sending teachers to watershed training sessions, and supporting restoration projects.

Examples of CREEC Activities

The Fish-Fest

The Fish-Fest was instrumental at developing support in local elementary schools for CREEC activities. Held in the Ochoco Creek Park, 1,200 students in grades K-3 attend. Students rotate through a series of nine to ten stations sponsored by local agencies. At these stations they learn about the local fishery resource and watershed and riparian concepts. Example of stations include Native American storytelling inside the salmon tent, costume parades, fish arts and crafts and the salmon life cycle game. Each classroom also has to provide one parent for every five students attending. This provides a great opportunity to educate adults as well as kids. The Fish-Fest has been a tremendous success and expands each year with new partners and stations. This activity has proven to be one of the most valuable projects that CREEC is involved in because it is a highly visible example to the community of what the partnership can produce.

The Student Intern Program

The Intern program comes very close to satisfying part of the Certificate of Advanced Mastery (CAM) requirements identified in the Oregon 21st Century Education Act. Students must meet a minimum GPA of 3.0 to apply for the program and are interviewed for available paid positions. Those selected collect data for a small research project identified by the cooperators. Following the fieldwork, the students are required to complete a technical report and make a formal presentation of the results of their study. This program was begun in 1994 with two students. With the addition of several new partners,by 1995 a total of eight students were sponsored by the program.

Ochoco Creek Instream Classroom

The Crook County School District is fortunate to have a stream running through school property. Ochoco Creek has been the focus of many CREEC activities including habitat improvement projects, riparian plantings, stream cleanups and discussion of stream dynamics. In addition, a stream gauge and weather station have been set up along the creek. These sites are being monitored by students from the high school and elementary school respectively.

CREEC Fair

A major portion of the partnership's budget in the first two years was used to purchase equipment. Equipment included CD ROM drives, videodisc, thermographs, current meters, water chemistry kits, Global Positioning Satellite units, and much more. We found initially that use of this equipment was surprisingly limited. Many teachers were either unaware of what was available or had no idea where it was stored even though equipment lists and locations were circulated among the teachers. The CREEC Fair was organized to show the teachers what was available and how it could be used in their classrooms. Held on a teacher in-service day, all teachers were invited to the middles school cafeteria where agency personnel demonstrated the equipment and described its uses.

Stearns Diversion Fish Salvage

Each Fall, teachers and students help State Fisheries Biologists by electroshocking rainbow trout and whitefish out of the major irrigation canal in the Crooked River drainage and placing them back in the river after irrigation season. Several thousand fish are annually saved in this effort. Students learn valuable fisheries management techniques and conservation ethics.

In addition to these programs CREEC has also been instrumental in facilitating more traditional types of educational activities. This would include arranging Resource Specialists to speak in classrooms, funding bus transportation for field trips, subsidizing vocational arts construction projects that benefit CREEC activities, and funding substitute teachers when needed to cover a teacher absent for a CREEC sponsored activity.

A new project for 1996 involves restoration of black cottonwood trees in the watershed. This once widespread riparian tree species is almost extirpated in many parts of Central Oregon. The Forest Service and BLM are currently propagating cuttings from many remnant clones on public land in two seed orchards as a means of saving the historic genetic material. This year Silviculturists and Ecologists from the Forest Service will give several lectures on the importance and management of black cottonwood to the High School Horticulture class. Following that, students from the class will assist USFS and BLM personnel in taking cuttings from the seedbed, preparing cages to protect plantings and planting the cuttings out in floodplains on public land. A smaller group of students will monitor survival of the plantings.

Elements of Success

The CREEC partnership has experienced a lot of success in a relatively short period of time. By all accounts we have one of the most successful educational partnerships in the State of Oregon. All this occurred in an underfunded, rural school district. Looking back it seems like there were several key elements that helped CREEC become a success. These elements are summarized below:

1. Partners took advantage of "Windows of Opportunities". There was a convergence of events (the watershed conference, NFWF tour and grant, passage of the 21st Century Schools Act) that CREEC was able to use as a springboard to success. People were organized and committed enough to the process to take advantage of the opportunities that were presented. We also turned the fiscal condition of the school district to our advantage when we were able to show that CREEC support could increase the number of opportunities available to students.
2. Key partners were committed to succeeding. As with most fledgling partnerships, a relatively small group of people did most of the work in getting CREEC off the ground. These people were supported by the agencies and organizations they worked for and were allowed to devote enough of their time and energy to keep the partnership moving ahead.
3. Accountability was built into the process. This applies to both financial matters and subtask completion. CREEC is run like a business. We carefully track and best utilize all of our resources. It is also important to fulfill obligations for projects and follow through on to completion. The quickest way to kill a program like this is to make grandiose promises to your partners and fail to meet their expectations. To this end, each person responsible for a subtask is required to fill out a completion form and return it to the project coordinator. A report to the CREEC committee is also required.
4. Marketing is emphasized. This has helped us stay in the funding loop both from an agency perspective in terms of staying competitive for Challenge Cost Share funds and also in our applications for various grants.
5. The importance of outreach and expansion is recognized. One of the keys to continued success is to branch out both in the schools and in the community. To date a relatively small number of people have been responsible for most of the subtasks that have been completed. Because of this it has been primarily single resource (fisheries) oriented. To avoid over-utilizing these people and in order to achieve a multi-disciplinary approach we need to involve other people to share the workload and the reward involved in working with the schools. That is why the two new subtasks for 1996 (Black Cottonwood Study and Prescribed Fire Ecology) are targeted for leadership by foresters and fire personnel. The same effort needs to happen at the schools. Although there are a lot of opportunities available, most teachers do not seem to make use of them. CREEC needs to do a better job of outreach and facilitating connections between agency representatives and teachers for specific projects.

Financing National Estuary Program Comprehensive Conservation and Management Plans: How to Identify and Implement Alternative Financing Mechanisms

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Web Note: *Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

Under EPA's National Estuary Program (NEP), Management Conferences around the country have prepared Comprehensive Conservation and Management Plans (CCMPs) to protect and restore natural resources in their estuaries. A key element of these plans is a funding strategy that identifies appropriate revenue-generating mechanisms to fund actions called for in CCMPs. To create this funding strategy, NEPs must first use cost estimation techniques such as workload analysis and categorical cost estimation to quantify the type and extent of present and future costs associated with the CCMPs. Programs can then select from a wide range of alternative financing mechanisms (AFMs) ranging from more traditional mechanisms_such as fees, taxes, grants, debt instruments, and voluntary donations to more innovative mechanisms_such as economic incentives, public-private partnerships, and others. In addition, programs must ensure that revenues from AFMs are expended to implement CCMP actions.

This paper first describes several techniques to identify and evaluate costs associated with CCMP actions. It then outlines a process for identifying funding alternatives that Apogee has developed in working with over a dozen NEPs and watershed management programs. The paper also reviews the use of benefits assessment in the financial planning process. Finally, the use of institutional mechanisms (such as nonprofit organizations) to raise and manage funds for CCMP implementation is discussed.

Cost Estimation and Financial Planning Techniques

NEPs need to identify the type and amount of present and future costs associated with CCMP implementation. Costs must be estimated both by dollar amount and by when the expenditures will need to be made. For example, some CCMP actions involve capital costs that require raising large sums over a relatively short period of time, while other actions involve ongoing operating costs continuing over a period of years. In looking at expenditures that will occur over time, NEPs should consider allowing for the effects of inflation as well as potential economic or fiscal changes.

Various financial management techniques can assist NEPs in identifying the types and extent of CCMP-related costs. For example, local governments typically use capital budgeting to assist in identifying capital costs to implement CCMP-related actions, such as stormwater improvements. Capital budgets are long-term financial plans that account for construction and upkeep of physical facilities owned by public entities. Where these capital budgets have been developed, NEPs can identify incremental capital improvements that relate to implementing CCMP recommendations.

Another technique that has assisted NEPs in estimating operating costs is workload analysis. Workload analyses detail costs of carrying out particular programs or activities. Using readily available measures such as numbers of permits or dischargers, estimates of time required to perform types of work in question, and estimated salary costs for an average full-time-equivalent (FTE), a program can estimate the costs of permitting and other labor-intensive activities.

A final technique is the use of categorical cost estimates. A categorical cost is a specific cost estimate (i.e., a price tag) that is assigned to a particular action each time it appears as a strategy implementation step. While categorical cost estimates may over- or underestimate a particular activity, these differences are assumed to average out as the costs of objectives are tallied. For example, Apogee assisted the Galveston Bay National Estuary Program (GBNEP) in developing cost estimates for inclusion in the Galveston Bay CCMP. Apogee identified groups of common actions among the several hundred CCMP implementation steps (e.g., regulation, education, legislation). For each category of common actions, categorical cost estimates were developed, and were used to generate portions of the total CCMP cost estimate.

Development of Initial Funding Inventories for Estuary Programs

Most NEPs identify potential AFMs through a scoping process that may involve workshops, public meetings, or seminars. These events can identify current funding sources, bring forth any innovative ideas that estuary managers or nonprofits may have, and educate both Management Conference members and the public on the financial planning process. For example, for the Albemarle-Pamlico Estuarine

Study, EPA funded a pilot financial workshop that introduced estuary managers to basic concepts of financial planning. In the Indian River Lagoon, Apogee and the IRLNEP Program Office conducted a series of workshops with members of the Finance and Implementation Task Force, scoping out potential AFMs and working with committee members on the financial planning process.

In addition, a number of guidebooks exist to help NEPs identify potential AFMs. The EPA Office of Water publication, Financing Marine and Estuarine Programs: A Guide to Resources (September 1988) is a good starting point. The Compendium of Alternative Financing Mechanisms produced by the EPA's State Capacity Task Force (revised January, 1996) is another general resource. These and other materials can be used to create an inventory of potential AFMs.

Planning Tools for AFM Evaluation

Once a preliminary list of AFMs is developed, it must be matched to the needs identified in the CCMP. Although the final matching exercise occurs with development of the funding strategy, the basis for it is developed in the funding inventory. Preliminary evaluations of AFMs can be used to narrow a broader list to a manageable size for use in development of the funding strategy. These preliminary evaluations include consideration of the following issues:

- What costs (both type and extent) will be incurred to implement specific CCMP actions;
- Whether a proposed AFM will generate enough revenue to cover these costs;
- Whether an AFM is legal under existing state and local laws;
- What its likely economic impacts will be;
- Whether it has any equity effects (i.e., charges polluters or beneficiaries fairly);
- How difficult it will be to administer; and
- Whether it will be politically acceptable.

Clearly, complete evaluation of any one of these aspects could involve expenditure of significant NEP resources. For example, a full economic impact study of a proposed tax increase could cost hundreds of thousands of dollars. While financial planning is critical to the success of any NEP, it is also important to develop a workable funding strategy with minimum expenditure of estuary resources. Customized finance evaluation and prioritization tools can help narrow options effectively and rapidly.

For example, in the Indian River Lagoon, three planning tools were created to guide decision makers through the financial planning process:

- Financing Option Profiles;
- Financing Option Comparison Matrices; and
- Financing Option/Management Action Matrices.

Financing Option Profiles

Financing option profiles provide preliminary descriptions of potential AFMs, including projected revenues, institutional and fund management requirements, and advantages and limitations. The profiles also can be coded by administering agency (e.g., state environmental agency, local department of public works) for easy reference.

Financing Options Comparison Matrices

Once preliminary information about each AFM is collected in profiles, the next step is to develop evaluative criteria that can be used to compare across funding options. These criteria will vary from NEP to NEP, but may include many of the issues covered in the profiles, including annual revenues, nature of revenue flow, administrative ease, economic impact, and so forth. Some of the criteria will be quantitative (e.g., minimum revenues needed) while others will be descriptive (e.g., administrative ease). In the development of the Indian River Lagoon funding plan, these criteria were developed through workshops with NEP stakeholders. Once developed, the criteria can be applied against the potential AFMs in an iterative process. (See Exhibit 1 for a segment of a comparison matrix).

Financing Options/Management Action Matrices

Once funding options are evaluated on their own merits, they can be matched with particular CCMP actions. An NEP may choose to require that a financing option that will be used for a particular action primarily generate funds from either those that contributed to causing the problem that the action seeks to remedy, or from beneficiaries of the action. For example, developers might be required to participate in a wetlands mitigation bank that would mitigate development impacts on wetlands.

Together ,these decision tools help guide the process of identifying funding options and linking these options to required actions in a systematic approach. This methodology allows NEP managers to draw on experience with other NEP programs as well as incorporate local circumstances through workshops with stakeholders and the public.

Benefits Assessment

Financial plans work best when they (1) demonstrate that all constituencies are paying a "fair share" and

(2) the benefits of CCMP actions are worth their costs. Most NEPs do the first step very well. But few estuaries pursue the second critical step: estimation of the benefits of CCMP implementation. Since estuaries are by definition coastal areas, and coastal economies are inextricably linked to healthy ecosystems, benefits estimation can be a powerful tool to demonstrate the merits of investment in resource restoration and/or protection. In the Indian River Lagoon, for example, incremental costs of CCMP implementation were estimated at less than $20 million per year. The Lagoon, on the other hand, was conservatively estimated to generate more than $800 million per year in value to the five-county area comprising its drainage basin. Clearly, even a small loss in value associated with degradation could jeopardize the strength of local economies, thus pointing to the importance of the implementation of CCMP actions.

Institutions for AFM Implementation

A final and crucial aspect to development of an NEP funding strategy is the role of institutions. Institutions can facilitate financing and implementation of estuary projects and programs. They can range from dedicated trust funds to organizations that directly facilitate implementation of AFMs selected. Institutional mechanisms also can facilitate or enable strategies that will reduce costs or increase revenues.

Institution as a Focal Point

The creation of an estuary-related institution can be particularly useful for serving as a focal point for the ecosystem that is being protected. The founding of an institution creates an identity for the ecosystem, which is critical to inspiring changes in polluting behavior. For example, creation of the Chesapeake Bay Program helped to bring the concept of an ecosystem to the general public; and provided an image to consider when thinking about pollution prevention, financing and other issues.

Pooling Funds

Institutions also can attract and pool funds from multiple sources and draw contributions from nontraditional sources (e.g., private funds, voluntary contributions, etc). Separation of funds from the local or state general funds can protect pooled revenues from the annual appropriations procedures. Finally, when funds can be carried over from year to year, revenues are not necessarily subject to spend-down requirements imposed on existing government entities.

Other Institutional Advantages

Because they can span several geographic areas, estuary management institutions can achieve economies of scale in administration, project scope and costs, and fundraising. The structure of institutions also can provide independence from state and federal regulatory agencies, providing some autonomy in program administration. Institutions also can foster coordination between different levels of government, especially if the institution is structured to span several levels of government, thus providing a link between various parties and a focal point for activities and responsibilities. Depending on design, charter, and powers, an estuary management institution also can be used to ensure that revenues from AFMs will be spent on CCMP implementation.

Conclusion

This paper describes only a few of the many steps required in creating a financing strategy for a CCMP. More information on financing for NEPs and for environmental programs in general is available through the EPA's Environmental Financial Advisory Board (EFAB) and its publications, as well as EPA's Environmental Financing Information Network (EFIN). In addition, NEPs are advised to look to the experience of other NEPs that have already been through the stages of funding inventory and funding strategy development.

Funding Mechanisms for a Watershed Management Program

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This paper describes the mechanisms used by Prince William County, Virginia, to fund the county's Watershed Management Program. The mechanisms described include a county wide storm water management fee, development fees, and grants and cooperative agreements. The Watershed Management Program is responsible for enhancing water quality, monitoring air and water quality, and protecting properties and the public from flooding.

Recent federal and state regulations require municipalities to control not only storm water quantity but also storm water quality. The EPA National Pollutant Discharge Elimination System (NPDES) storm water program, the Chesapeake Bay Preservation Act, and the Virginia Storm Water Management Act require treatment of storm water and control of non-point source pollution for existing and new development.

Storm Water Management Fee

Recognizing the costs impacts of the above mentioned regulations, the Virginia General Assembly provided a new funding mechanism for localities, the storm water utility. Section 15.1-292.4 of the Code of Virginia allows local governments to implement service charges to finance storm water related activities.

The Watershed Management Program in Prince William County was funded by the General Fund up to 1994. However, funding levels changed from year to year depending on the needs of other county programs. A reliable and equitable source of funding was needed in order to meet stringent regulations and local needs of the county's watersheds and storm water management system.

The Prince William County Board of County Supervisors established a Storm Water Management Fee (storm water utility) in March of 1994. Residential property owners pay $1.50 per month for detached single family homes. Townhouse and condominium owners pay $1.13 per month. Non-residential property owners pay $0.73 per one thousand square feet of impervious area. Fee adjustments or credits are available for non-residential properties.

Some of the activities funded by the storm water management fee include control of storm water runoff, restoration of streams, maintenance and repair of drainage systems (the county maintains approximately 130 miles of drainage systems and 250 storm water management facilities), construction of projects to minimize flood hazards and non-point source pollution, water quality monitoring, and completion of 32 watershed management plans. These plans consist of hydrologic and hydraulic models, water quality analysis, environmental resources inventories, and pollution prevention activities. The pollution prevention activities are carried out in coordination with the Prince William Soil and Water Conservation District and Virginia Tech's Cooperative Extension Service.

Informational Workshops

Several workshops were organized for county staff during 1992 and 1993. The purpose of the workshops was to "educate" staff on the benefits and options available to fund watershed management activities, and to identify concerns and issues that needed to be resolved before establishing the storm water management fee. The workshops were also used to identify individuals in the different county departments, Finance, Management and Budget, Technology and Support Services, and the Office of the County Attorney, that will be involved with the implementation of the storm water management fee.

Feasibility Study

In February 1993, a feasibility study was prepared for the Board of County Supervisors. The feasibility study presented the following information:

- The funding requirements of the proposed storm water management program included capital improvement projects, maintenance activities, engineering activities, and funds needed for the preparation of the NPDES permit applications.
- The rate structure defined a base unit as the typical single family residential property. A pilot

study was completed to determine the size of the base unit. A range of potential revenues were provided based on different rates for the base unit.

- Several billing system options that were analyzed. The study recommended to include the storm water fee in the real estate billing system.
- Recommendations for implementation of the storm water utility.

The Board of County Supervisors accepted the recommendations of the study on July of 1993 and directed staff to proceed with implementation.

Development of Administrative Policies

The following administrative policies were developed during the implementation of the storm water utility:

Base Unit. The base unit is the total impervious area of a typical single family residential property in the county. The base unit in the county equals 2,059 square feet.

Base Rate. The base rate is the monthly storm water management fee charged on a base unit, and is established by the Board of County Supervisors by resolution.

Rate Structure. For purposes of determining storm water management fees, all properties within the county are classified as developed residential property, developed non-residential property, or undeveloped property.

Single family detached residential properties are charged the base rate for each dwelling unit, regardless of the size of the parcel or improvements. Townhouses, apartments and condominiums will be charged a flat rate of seventy-five percent of the base rate.

The monthly fee for developed non-residential property is the base rate multiplied by the numerical factor obtained by dividing the total impervious area of the property by one base unit.

Undeveloped property is exempt from the fee. Properties owned by federal, state, or local government agencies are also exempt when those agencies own and provide for maintenance of the storm water management system.

Owners of agricultural croplands are not charged a fee. Agricultural properties are currently required to develop water quality plans and resource conservation plans in order to comply with the Chesapeake Bay Preservation Act and the Farm Bill.

Fee Adjustments. Developed non-residential property where storm water management is provided by the owner on-site, and where the owner has entered into an appropriate storm water maintenance agreement with the county, may be eligible for fee adjustment, in proportion to the level of storm water management controls on the site. Non-residential property owners are also eligible for fee adjustments by participating in pollution prevention or storm water quality protection programs. Such programs include an adopt-a-pond program, volunteer lawn program, adopt-a-stream program, etc. The maximum fee adjustment is limited to fifty percent of the fee.

Maintenance Policy. The maintenance policy states that the county maintains all drainage systems and storm water management facilities in residential areas. The county is also responsible for maintenance of detention (dry) storm water management facilities in non-residential properties. Non-residential property owners are responsible for maintenance of drainage systems and storm water management facilities, other than dry ponds.

Storm Water Assessment (SWA) System

The SWA system is a client/server application designed to calculate storm water utility revenues and assist users in answering customer questions related to fee basis.

The County's Geographic Information System (GIS) was used to calculate the impervious area of each developed parcel within the county and to develop the base unit. The Real Estate Assessment System provided information on account numbers, owner names and addresses, property addresses, and land use. The SWA system "ties" all these systems together and generates a storm water management fee for each owner. The SWA system provides the following functions:

- Import customer information from the Real Estate Assessment System.
- Import impervious area data for each parcel from the County's GIS.
- Calculate storm water management fees for each parcel.
- Export fee data to the Real Estate Assessment System for billing and collection.
- Provide a means for Watershed Management staff to respond to customer inquiries regarding the basis for fees billed.
- Provide reconciliation reports to the County Cashier.
- Provide billing Summary Reports.

Public Information

Keeping the public informed of the process of establishing a storm water utility and obtaining feedback on the different policy issues are important components of a successful implementation. The public information "campaign" extended throughout the duration of the project.

Newspaper articles and cable television news releases were some of the most cost-effective techniques used to keep the public informed. Feedback on policy issues was obtained through numerous meetings with different interest groups.

On March 15, 1994, an ordinance was adopted by the Board of County supervisors establishing the Storm Water Management Fee and adopting the aforementioned policies.

Development Fees

Development fees are used to fund development related activities of the Department of Public Works (transportation and watershed management activities) and the Office of Planning.

Development fees are collected when a plan is submitted to the county for review. The fee is based on the size of the development and the complexity of the drainage system. These fees are used to fund plan review activities and administrative requirements. Staff of the Watershed Management Program reviews plans for compliance with the county's environmental ordinances and regulations. These ordinances and regulations address design of drainage systems, flood plain management requirements, erosion and sediment control requirements, Chesapeake Bay protection requirements, design of storm water management facilities, buffers and tree preservation requirements, and wetlands requirements.

Once a plan is approved, and the developer "pulls" a land development permit, additional fees are collected. These fees are used to fund inspection of storm water management facilities and drainage systems, and enforcement of erosion and sediment control regulations. Inspections of drainage systems and storm water management facilities after the development is completed are funded by the Storm Water Management Fee.

When a storm water management facility is not feasible on a development site or when a storm water management waiver is obtained by a developer, a storm water management pro-rata share is paid by the developer. The pro-rata share is based on the impervious area of the site and the proposed land use type.

The pro-rata share funds are maintained in accounts for each of the ten major watersheds. The funds have to be used in the watershed where the development project was located. These funds are used for projects that have watershed-wide benefits.

Grants and Cooperative Agreements

The funds collected through storm water management fees and development fees are used to fund the operations of the Watershed Management Program and program specific projects. Grants and cooperative agreements with state and federal agencies and private entities are used to complement these revenue sources by funding special projects or activities.

Examples of these type of special projects include water quality monitoring with the USGS, stream and wetlands restoration with the U.S. Fish and Wildlife Service, and the construction of a sediment forebay to protect a local lake in coordination with the Lake Montclair Property Owners Association. In addition, Prince William County is participating in the development and implementation of an innovative watershed management project with EPA, other federal and state agencies, and local universities.

Summary

Identifying innovative sources of funding is becoming a necessary activity for local governments. The tree funding mechanisms described above provide Prince William County with a reliable source of funding to protect its water resources and to comply with state and federal regulations.

Financing Priority Watershed Projects with the State Revolving Fund

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Introduction and Overview

SRF Loan Program Features

- Interest Rate: 0% to Market Rate
- Repayment Period: Up to 20 years
- Adjustable-rate loans, stepped payments, balloon pyaments allowed at state discretion
- Loans cover 100% of eligible costs
- Repayment begins one year after project startup
- Loans available for wastewater, nonpoint source, and estuary projects

The SRF program was created in 1987 to replace and improve upon the foundation laid by the Construction Grants program which existed from 1972 through 1990. Congress' primary objective in creating the SRF program was to establish permanent sources of financing for surface water-related infrastructure projects in each of the 50 states and Puerto Rico. (The Administration has proposed setting up a separate SRF to address drinking water needs.) By moving from a grant program to a loan program, the federal government could provide initial capitalization funds to set up these new revolving funds and reduce its day-to-day role in infrastructure financing. Another goal of this new program was to expand the uses of these funds far beyond municipal wastewater systems (which were the primary recipients of the Construction Grants program) to include virtually all surface water-related infrastructure projects. Under the SRF program, loans can be made for a wide variety of nonpoint source, estuary, stormwater and other projects that are intended to benefit the nation's surface and ground water resources. The SRF program currently has in excess of $17 billion in assets and provides below-market loans to communities and individuals for up to twenty years.

Meeting Today's Water Quality Needs

In the 1970s, discharges from municipal wastewater systems were one of the major sources of the serious pollution problems threatening the nation's water resources. In response, Congress created the Construction Grants program to assist municipalities in addressing these threats to human health and the environment. After nearly 20 years and a federal investment of more than $60 billion, most of these large-scale threats to water quality have been successfully dealt with. As a result of this progress, the challenges ahead are very different from those of the past. Today most of our pollution problems are caused by literally millions of diffuse sources that are difficult to identify and often beyond the scope of our existing regulatory authorities.

SRF Investment ($ billion)	
Federal SRF Investment (FY 88-96)	$11.4
Required State Match	$ 2.3
Proceeds from Leveraging (bonds)	$ 5.2
Additional	$ .6
Bond Reserve Funds	($ 2.3)
Amount Available for Loans	$17.2

During the first few years of the SRF program, the vast majority of assistance was provided for municipal wastewater projects. In response to the changing nature of water quality problems, the SRF has begun to devote an increasing volume of loans to nonpoint source and other water quality projects. However, because of the program's history and connection with the Construction Grants program, many potential customers are unaware that the SRF could serve as a source of funding for such projects. The SRF can fund both ground and surface water projects. It can fund stormwater projects in urban, suburban, and, in some cases, industrial or commercial settings. Nonpoint source projects may include virtually any project or type of project that a state has identified in its nonpoint source management plan, including projects to correct runoff from agricultural land and feedlots, conservation tillage and other projects to address soil erosion, development of streambank buffer zones, as well as wetlands protection and restoration. Estuary management projects may include any of the above and also such projects as fish restocking, wildlife habitat restoration, marine sewage pump-out facilities, and many others.

Leading Causes of Pollution		
Rivers	**Lakes**	**Estuaries**
Agriculture	Agriculture	Municipal
Municipal	Urban Runoff/ Stormwater	Urban Runoff/ Stormwater
Urban Runoff/ Stormwater	Hydro/Habitat Modification	Agriculture
Mining	Municipal	

Connecting the SRF to the Watershed Approach

EPA's Office of Water instituted the watershed approach around 1989 in recognition of the changing nature of the threats to our nation's water resources. While water quality has improved dramatically, our work is far from complete. Our pollution abatement work of the past has uncovered a completely new range of problems in need of attention. As was mentioned earlier, we must now contend with millions of diffuse sources of pollution. No longer are we faced with the challenge of massive discharges from relatively few pipes. Today, the sources are small, subtle, and often intermittent and come from nearly every aspect of society. We must concern ourselves with such problems as runoff from agricultural and urban land, short and long-range atmospheric deposition, and habitat alteration and destruction from all sorts of land use activities. Further, the mix of pollution sources affecting one river is probably significantly different from those affecting a nearby lake and completely different from those impairing a distant estuary. Clearly our national, one-size-fits-all tools are no longer entirely appropriate for the job ahead.

In recognition of the trends and changes, the watershed approach was developed to reorient our CWA programs to develop the appropriate solutions for the specific problems being faced by a particular river, stream, lake, coastal area_or more simply a watershed. Further, the concept of watershed planning recognizes that regulatory tools alone will not be enough to meet these challenges. In this new paradigm, traditional tools need to be combined with newer non-regulatory tools to fashion solutions in the quickest and most cost-effective manner possible. Within this context, SRF loans are valuable and effective tools. SRF loans can be used to reach and address sources of pollution beyond the reach of our traditional regulatory framework. Because the SRF offers substantial subsidies over commercial sources of financing, the strategic targeting of SRF loans may allow many new organizations and individuals to participate in protecting their local water resources.

SRF Funding Framework Options

Over the first seven years of the State Revolving Fund program, state interest and innovation in addressing and funding projects to address nonpoint sources of pollution have increased substantially. As the program moves toward funding a greater variety of projects, including nonpoint source, estuary management, as well as traditional point source projects, the SRF_with its substantial but still limited resources_will need to ensure that it has the ability to direct its funds to the highest priority projects. In setting priorities for funding, the 51 SRF programs must consider a set of complex objectives which are sometimes in conflict and include maximizing environmental (public health and ecological) benefits and providing assistance to recipients most in need of assistance (small and disadvantaged communities). The SRF must also survive financially, therefore, SRF managers must carefully manage financial risk to ensure the long-term fiscal health of their funds.

SRF Loan Savings		
		Approximate savings with SRF twenty-year loan
Typical municipal borrowing rate in commercial market	7.5%	
Average SRF Rate	3.0%	30%
Lowest SRF Rate	0.0%	50%

Under the current framework of legislation, regulations, and policies both at the federal and state level, the 51 SRF programs have planning procedures adequate to successfully direct funds to traditional wastewater projects. The current procedures generally allow states to successfully identify relatively important wastewater projects and then to select relatively low-risk projects from among those priorities. Each state undertakes an annual planning cycle for its SRF funds. This process includes consideration and selection of wastewater projects from the state's project priority list, and may also include consideration and selection of projects or activities from the state's nonpoint source and estuary management plans. States develop annual Intended Use Plans in which they gather together information on a list of potential projects and solicit input from interested parties and the public in general. After completion of this process, loans are made to applicants.

As the universe of potential loan applicants expands to include a wide variety of nonpoint source and estuary projects (farmers, conservation groups, citizen action groups, gas stations, landfills, businesses, etc.), the need to effectively evaluate the potential environmental importance as well as the financial risk of projects increases and grows in complexity. The planning and priority setting procedures in place in many of the 51 SRF programs were not designed to determine priorities from a greatly expanded universe of potential projects that includes nonpoint source and estuary activities. EPA believes that improvements must be made to these procedures to ensure that SRF funds continue to be directed to the highest priority projects without jeopardizing the long-term health of the program.

Based on these concerns, EPA has engaged in a policy setting dialogue with the states, as co-regulators. Accordingly, state and federal representatives have been meeting since June 1995 with the goal of reaching a consensus on a policy framework. Currently, that process is nearing completion and should result in a guidance document that includes two related options. These options suggest ways that states can evaluate current environmental priorities and develop a list of priority projects or geographically-specific activities (including wastewater, nonpoint source and estuary) appropriate for SRF funding. EPA's preferred option is for the creation of integrated priority setting systems that establish relative priority among wastewater, nonpoint source, and estuary projects according to states' environmental priorities. The second option is a "goals" approach in which states assess their water quality problems, determine overarching priorities, and finally set broad funding goals for the SRF based on this information. Both options are intended to enhance states' planning and priority setting efforts and to utilize existing sources of information. Decision making for the SRF program will remain entirely a state responsibility. Over the longer term, these options are intended to help states make the transition toward full watershed planning and priority setting.

This policy is intended to come on line over the next two years. In the interim, EPA plans to offer a wide variety of training and other forms of assistance to the states and interested parties to further the implementation and adoption of these principles. EPA plans to sponsor a series of workshops and is also offering funding for state pilot projects to develop and implement the planning and priority setting aspects of this policy. Further, EPA plans to work with interested organizations to develop training and educational opportunities over the next several years.

These efforts, including implementation of this policy, are designed to help states integrate the SRF program into their overall efforts to protect and enhance water quality and provide them with the tools necessary to effectively target SRF resources to their highest priority water quality problems. The success of this effort hinges upon cooperation among all parts of the water program including point source, nonpoint source, estuary, and watershed programs. It also requires open and meaningful participation by the interested public. It is our hope that these efforts will serve as a catalyst for state water programs to work together to improve the planning and priority setting aspects of their SRF programs and to foster greater public input and participation.

For additional information contact the State Revolving Fund Branch of the U.S. Environmental Protection Agency, 401 M St. SW, Mail code 4204, Washington, D.C. 20460 or contact Cleora Scott, Sheila Hoover, or Nikos Singelis at (202) 260-7359.

The Fox Wolf Initiative

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Background

The Fox-Wolf Basin and Lower Green Bay are heritage resources of regional and international significance and are an integral part of the Great Lakes ecosystem. The Fox-Wolf Basin encompasses a land drainage area of 6600 square miles and makes up approximately 40% of Wisconsin's Lake Michigan drainage basin. The Fox and Wolf Rivers, Winnebago Pool Lakes, and Lower Green Bay have suffered a decline in water quality and living resources as a result of pollution and habitat loss. Lower Green Bay has been identified as an Area of Concern by the International Joint Commission on Great Lakes. Basin plans, the Green Bay Remedial Action Plan and the Lake Winnebago Comprehensive Management Plan list sediments (TSS) and phosphorus (P) as the two most pervasive pollutants threatening the integrity of the Fox-Wolf System. These plans have specific recommendations for the reduction of suspended solids and phosphorus loads to Lake Winnebago and Green Bay by 30% and 50% respectively.

Northeast Wisconsin legislators, industry, environmental groups and citizens at large in the basin are concerned about the fate of this ecosystem. They would like to see a priority action on a large-scale geographic basis to meet the objectives set by these plans. The Fox-Wolf Initiative was developed in response to public demands for clean water in the Fox-Wolf Basin. The Initiative provides a long range framework for integrating existing Wisconsin Department of Natural Resources (WDNR) programs with other agencies, local governments, and public and private sector interests. It will guide water quality restoration and protection efforts in the Fox-Wolf Basin over the next two decades and will serve as a pilot for the nonpoint pollution abatement efforts in various basins in the state. This paper discusses the guiding principles and implementation elements for the Fox-Wolf Initiative.

Nonpoint Pollutant Sources

Fox-Wolf Basin 2000, a nonprofit organization in the basin, hired an analysis team (consisting of engineers, economists and a number of professors at the University of Wisconsin, Green Bay as consultants) to quantify various sources of nonpoint source pollution and their relative contributions to Lake Winnebago and Green Bay. The team has estimated the TSS & P loads from all 40 watersheds in the study area using the SWRRBwq (Simulator for Water Resources in Rural Basin-Water Quality) model. The model predicted nonpoint pollutant loadings based on soils, topography, and typical cropping practices. It estimated that point and nonpoint sources of pollution deliver more than 1.5 million tons of total suspended solids and more than 2.6 million pounds of phosphorus into the waters of the Fox-Wolf Basin. Agricultural sources accounted for 92% of the suspended solids and 83% of the phosphorus. By the time the waters reach Green Bay, agricultural sources represent 89% of the suspended solids and 74% of the phosphorus. The team has also estimated that the costs of controlling TSS and P from agricultural sources are much smaller than the costs for urban areas and municipal and industrial sources.

The modeling clearly indicates that agricultural nonpoint sources of pollution are the primary cause of water quality degradation in the basin and provided an opportunity for WDNR to make pollutant allocation decisions on a geographic basis. The Fox-Wolf Initiative therefore focusses on providing the greatest abatement of and protection from agricultural nonpoint source pollution. However, other pollution abatement efforts such as stream bank restoration, point source phosphorus control, and urban nonpoint source pollution abatement will also continue in order to maintain a balanced approach to water quality management.

Guiding Principles and Objectives

Four principles served to guide the development of the Initiative. These principles are:

- Restoring and protecting the health of the aquatic ecosystem will benefit the people of Wisconsin and the fish and wildlife of Green Bay, the Winnebago Pool lakes, and their tributary lakes, streams, and rivers.

- The WDNR cannot, through unilateral action, adequately restore or protect the waters of the Basin.

- County and municipal governments, conservation groups, the public, and state and federal agencies must cooperate to restore and protect the waters of the Fox-Wolf Basin.

- Whenever possible outside funding sources will be sought to help meet the financial needs of the Initiative.

The Objectives of the Initiative are grouped into Restoration and Protection categories:

Restoration Objectives

- Improve the recreational attractiveness of lakes and streams for swimming, boating, and fishing by improving water clarity and reducing sediment deposition.

- Promote the establishment of rooted aquatic vegetation which favors balanced game fish and forage fish populations.

- Improve ecosystem biodiversity by creating diverse habitats for fish and wildlife.

- Stabilize eroding streambanks while improving fish and wildlife habitat.

Protection Objectives

- Promote individual and collective awareness of the relationship between land management decisions and nonpoint source water quality impacts.

- Promote the adoption of ordinances, policies, and programs which reduce nonpoint source pollution and improve fish and wildlife habitat.

- Create and preserve vegetative buffer zones along streambanks to reduce the direct discharge of polluted runoff into lakes, streams, and rivers while preserving fish and wildlife habitat.

- Continually assess the progress of the Initiative as it is being implemented through surveys, monitoring, and modelling, so that necessary changes can be identified and implemented as needs require.

Implementation Elements

The major categories of recommended action divide into four "implementation elements". Each element is achievable through the implementation of specific tasks. The tasks are manageable, single focus, activities to be carried out individually or cooperatively by agencies, governments, and organizations.

The four Implementation Elements are:

1. Reduction of Total Suspended Solids and Phosphorus

The key to improving the water bodies of the Fox-Wolf Basin lies in controlling suspended solids and phosphorus which cloud the water and degrade aquatic habitat. Agricultural nonpoint source pollution is the primary source of these pollutants in the basin.

Wisconsin's Nonpoint Source Pollution Abatement Program is the most significant program operated by the WDNR and Department of Agriculture, Trade, and Consumer Protection for the control of nonpoint sources of pollution throughout the state. A number of watersheds are selected each year as priority watersheds (PWS) and funds are provided for the cost sharing of best management practices to control various nonpoint source pollutants such as nutrients, suspended solids and heavy metals. The Initiative has identified an accelerated selection of 18 watersheds as Priority Watershed projects over the next five biennia in the Fox-Wolf Basin. Achieving a high level of runoff control through Priority Watershed projects will improve local water resource conditions and will meet the nonpoint reduction goals of the entire basin.

Acre for acre, construction sites produce more sediment runoff than any other land use. In order to reduce this pollution source, the Initiative recommends the development of a well coordinated, comprehensive construction site erosion control program to reduce sediment delivery from construction sites. This activity will facilitate the development of local funding strategies to finance ordinance administration and will include work with local technical schools and colleges to develop course curriculum on erosion control in appropriate career fields.

Stormwater runoff from urban and urbanizing areas is another important nonpoint pollution source. The Initiative seeks to ensure comprehensive stormwater management planning and control throughout the basin. This will be accomplished through local adoption of stormwater ordinances consistent with the state model ordinance. Areas will be identified which have complex runoff issues requiring development of and implementation of detailed watershed-based stormwater management plans. This task will be accomplished by working cooperatively with regional planning commissions, local governments, and private sector consultants.

2. Restoration and Protection of Riparian Habitat

This element will result in the restoration and/or protection of thousands of acres of wetland, grassland, lake shore, and streambank habitat through the establishment of permanent vegetative buffer zones along water courses. It will improve water quality by reducing erosion and filtering upland runoff. Fish and wildlife populations will benefit from the creation, restoration, and protection of riparian habitat.

Within the Fox-Wolf Basin are many miles of shore land habitat approved for voluntary acquisition or easements through WDNR's Fish Management and Wildlife Management programs. These lands occur along the Wolf, Embarrass, and Red rivers and a number of other rivers and streams. Lands that are acquired or eased are maintained in vegetative cover to reduce erosion, provide filtering of upland runoff, and provide fish and wildlife habitat. This is a very valuable tool that will protect and rehabilitate stream segments threatened by agricultural nonpoint pollution sources. A concerted effort to pursue these lands will be accomplished by possibly the shifting of acquisition priorities from other areas in the state to the Fox-Wolf Basin.

Wetland and grassland restoration projects are important to water quality by reducing soil and nutrient delivery to water bodies. They also provide valuable habitat and aid in flood control. The Initiative recommends an annual goal of creating 30 wetland basins and restoration of 500 acres of grassland habitat.

It is important to continually seek to identify and evaluate stream segments for possible inclusion in department habitat restoration and protection programs. This task can be accomplished by existing staff, but a concerted effort to identify and evaluate potential sites will require a shift in priorities to the Fox-Wolf Basin. In addition, an element of the Priority Watershed program that has not yet been fully utilized is the reduction of nonpoint source pollution through better integration with Wildlife Management habitat protection and enhancement programs. Through an integrated effort both programs would benefit. Wildlife enhancement and protection will be more fully addressed on farms participating in the program while at the same time providing water quality protection.

3. Modelling, Assessment, and Data Management

Accurately determining existing and future water quality, biological, and habitat conditions and integrating land use information is essential for managing and determining the success of the Initiative. This element will define nonpoint source pollution loads, help evaluate the success of reducing nonpoint source pollution, identify additional nonpoint source pollution hotspots, and help establish pollutant reduction goals in Priority Watershed projects.

An essential element of a water quality initiative of this scope must include appropriate water quality monitoring. Monitoring data will be used to gauge the success of the Initiative by determining water quality at certain points in the basin to identify changes through time. It will serve as a means of documenting the level of pollutant reduction achieved. Monitoring will require the establishment of fixed-site trend monitoring stations at appropriate locations in the basin. Monitoring would determine temperature, dissolved oxygen, biochemical oxygen demand, phosphorus, total suspended solids, various nitrogen compounds, and possibly other parameters such as pesticide concentrations.

A geographic information system provides a means to map and create map overlays of various features of the land and land use information. For instance GIS can be used to overlay agricultural land use, well locations, and streams on maps showing municipal boundaries. It is a tool which is extremely valuable for integrating environmental data sets with land use information. It is proposed that appropriate GIS information layers be developed for the Fox-Wolf Basin to improve land management decision making capabilities of the department and local governments.

4. Public Information and Education

Support and cooperation of the general public, local units of government, and various clubs, organizations, and groups is essential for the success of the Initiative. A host of opportunities for active involvement by this diverse group will be identified as the initiative is implemented. This element will help foster an understanding and sense of responsibility for water quality management at the local level. It will result in wise land use management decisions which will reduce current nonpoint source pollution loading and protect waters from the threat of future nonpoint impacts.

A Citizen participation program will be developed for the Initiative. It's implementation will be critical for the success or the Initiative. The goal of citizen participation in this effort is to help all parties concerned reach an effective agreement on a course of action. A complete citizen participation plan for the Fox-Wolf Initiative will include the following major steps and concepts:

- Using meetings, surveys and other techniques to learn how citizens understand the problem.
- Preparing a public information program that will explain the agency's view of the problem.
- Cooperating with a regional or watershed coalition of governments and interest groups, possibly made up of sub-regional coalitions, who will work together on the development of a plan.
- A process of consensus and negotiation, reached through the coalition/s, that will form a substantial, effective agreement on what to do.
- Involvement of interested parties throughout plan implementation.

It is important that local communities participate in the Initiative as willing partners in nonpoint pollution abatement. It is proposed that a concerted effort be put into establishing a positive cooperative relationship between the department and local governments. Through this relationship it will be possible to encourage communities to voluntarily adopt ordinances, policies, and programs to substantially reduce nonpoint source pollution.

Timeline

The initiative is scheduled to occur over the next 20 years, starting with the 1995-1997 Biennium and concluding with the completion of the last Priority Watershed project in the year 2017. The ultimate success of the Initiative depends upon developing strong partnerships with local governments, user groups, regional planning commissions, and state and federal agencies, along with a strong commitment from the state government.

Through the support and cooperation of all parties concerned, the Fox-Wolf Initiative represents the best hope for a new beginning; the best hope for restoring and protecting the aquatic resources of the Fox-Wolf Basin for the people of Wisconsin.

The Hackensack Meadowlands Special Area Management Plan (SAMP): Using a Watershed Approach to Achieve Integrated Environmental Protection

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***Web Note:** Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

The Hackensack Meadowlands District (District) is a 32 square mile area located in northeastern New Jersey, in Bergen and Hudson Counties. The District comprises all or parts of fourteen municipalities, and is located approximately five miles west of midtown Manhattan and about six miles north of the Port of Newark. The District currently contains approximately 8,500 acres of wetlands, and 11,000 acres of upland, or about half of the historic wetland area, and comprises much of the lower watershed of the Hackensack River. Most of the upland areas are developed, and host primarily industrial, institutional, and commercial land uses.

The District originally contained approximately 17,000 acres of wetlands, including large areas of swamp dominated by Atlantic white cedar, Chamaecyperis thyoides. Over time, much of the wetland area was drained, diked, and ditched for agriculture and/or mosquito control. Hydrologic alterations occurred as the result of tide gate installation on many of the creeks, and upstream impoundment of the Hackensack River for water supply purposes. This latter influence resulted in salt intrusion to the lower Hackensack, which destroyed the remaining white cedar stands and many of the associated plant species. Today, the Meadowlands is dominated almost completely by large, nearly monotypic stands of the common reed Phragmites australis.

In addition to the landscape alterations, the Meadowlands has been the recipient of gross pollution in the form of extensive landfills and unregulated solid waste dumping, wastewater discharges, sewer discharges from two counties, and haphazard filling for development. This has resulted in degradation and loss of some of the most significant tidal wetlands in the Metropolitan region. The District currently contains approximately 1,200 acres of unclosed landfills, which discharge an estimated 650 to 800 million gallons of leachate into the District's wetlands and waterways each year (HMDC, pers. Comm.; Clinton Bogert Associates, 1990). In addition, there are over 200 known or suspected hazardous waste sites, including three Superfund sites, as well as numerous combined sewer overflows, which cause ongoing and cumulative degradation of the District's environment.

In spite of these various losses and degradation, however, the Meadowlands is one of only two remaining large tracts of estuarine wetlands, and also of open space in the N.Y. metropolitan area. Because habitat in the New York metropolitan region is scarce, the position of the Meadowlands in the landscape makes it highly valuable to fish and wildlife, particularly to migrating birds. Over 260 bird species are known to use the Meadowlands wetlands for some portion of their life history; at least 60 species nest there (EPA, 1989), and it is highly valuable as overwintering habitat for a number of waterfowl and raptor species (EPA, 1992). In addition, the Meadowlands supports reptile and commercially harvested mammals. The Hackensack River, although closed to fishing for human consumption, provides habitat for a number of estuarine and freshwater fishes. Consequently, the District still provides important habitat functions despite its existing pollution problems.

Land use management within the District occurs at a regional level. The Hackensack Meadowlands Development Commission (HMDC) is the Regional Zoning and Planning Authority for the District, as well as Regional Solid Waste Management authority within the District. The HMDC has a unique environmental mandate combined with these other powers, and is statutorily directed to provide for, "orderly, comprehensive development" in the District, while ensuring "special protection from air and water pollution" and recognizing "the necessity to consider the ecological factors constituting the environment of the Meadowlands and the need to preserve the delicate balance of nature" within the District (N.J.S.A. 13:17-1). The proximity of the District to both New York City and to the Port of Newark, combined with the presence of a major highway, freight rail and commuter rail lines through the District and the general scarcity of land in the New York metropolitan region, have led to increasing development pressure on the District's remaining wetlands, of which between 60 and 75 percent are privately owned.

In 1972, the HMDC introduced the first Master Plan for the District, which called for the placement of fill in about 2,600 acres of the District's remaining wetlands for development. This Master Plan was developed prior to the Clean Water Act (CWA), and consequently was out of compliance with the CWA from its inception. Over the last twenty years, this has led to conflicts between developers, who seek to develop within the District according to the Master Plan, and regulators, who must make decisions on applications by developers for permits to fill wetlands. This case-by-case method of evaluation was fraught with conflict and delay. It caused great uncertainty and extensive time delays for those applicants seeking permits for development which required wetland fill. Furthermore, it limited the ability of the agencies to evaluate the District as a system when making decisions, and thus did not ensure the best protection for the District's significant aquatic resources.

In order to better evaluate the District's wetlands as a whole, and to provide guidance for decision making on Federal 404 permits, the U. S. Environmental Protection Agency (EPA), the New York District Army Corps of Engineers (Corps), the HMDC, the U.S. Fish and Wildlife Service (FWS), the New Jersey Department of Environmental Protection (NJDEP), and the National Marine Fisheries Service (NMFS), undertook a joint effort to collect data to develop an Advanced Identification (AVID) of the Meadowlands. The agencies evaluated 92% of the District's wetlands, using the Wetland Evaluation Technique (WET). The final AVID, which became effective on December 10, 1992, designated approximately 88% of the District's wetlands as generally unsuitable for fill, between 2-3% of the wetlands as potentially suitable for fill, and approximately 9% of the wetlands in the District as indeterminate. It provided greater certainty to the regulated public, as well as better information for the purposes of decision-making on the part of the Federal agencies. However, the AVID alone was still unable to resolve the conflicts between the District's existing Master Plan and the requirements of Section 404 of the CWA. It furthermore could not address potential solutions to the ongoing degradation of the District's wetlands and waterways from uncontrolled pollutant sources. Since the District was under ever-increasing development pressure, the need to resolve the conflicts between the existing Master Plan and Section 404 of the CWA, as well as other Federal statutes, was imperative.

In 1988, the HMDC was undertaking revisions to its existing Master Plan, and expressed a desire to work in concert with the State and Federal agencies which had jurisdiction over wetlands in the District. In consequence of this, EPA, the Corps, and NJDEP entered in 1988 with the HMDC into a Memorandum of Understanding (MOU) to prepare a Special Area Management Plan (SAMP) for the District. A SAMP is defined in the 1980 amendments to the Coastal Zone Management Act as a "comprehensive plan providing for natural resource protection and reasonable coastal-dependent economic growth, containing a detailed and comprehensive statement of policies, standards and criteria to guide public and private uses of lands and waters; and mechanisms for timely implementation in specific geographical areas within the coastal zone". Corps regulatory guidance specifies that, in order for the development of a SAMP to be considered appropriate, the area under consideration must be environmentally sensitive and under strong development pressure. In addition, the development of a SAMP requires a local sponsor, since the Federal government does not have the authority to perform local land use planning, and requires public coordination. Finally, the SAMP must result in a set of definitive regulatory products.

The SAMP, as specified in the MOU, will be a comprehensive plan providing for natural resource protection and reasonable economic growth in the District, including preservation, restoration, and enhancement of the District's natural resources. The SAMP will also foster compliance of future development with applicable environmental laws and regulations, including the Clean Water Act Section 404(b)(1) Guidelines. As part of this, the parties to the MOU agreed that the final SAMP would result in no net loss of wetland functions and values within the District. Because the preparation of a SAMP was considered by EPA and the Corps to be an action which could have potentially significant consequences on matters under their jurisdiction, the agencies committed in the MOU to prepare an Environmental

Impact Statement (EIS) on the SAMP. EPA and the Corps are co-lead agencies in the preparation of the SAMP EIS. The Draft EIS was issued on July 21, 1995, and public comments were received until December 1, 1995. The plan is currently being examined and modified where appropriate in response to the comments received.

Development of the SAMP

Public Coordination

Because the Corps guidance on SAMPs requires public participation, a Citizens' Advisory Committee (CAC) was established from among the different groups of stakeholders in the SAMP, in order to assist in identifying issues and to provide ongoing review and comment as the EIS and the SAMP products were developed. The CAC comprises twenty members, drawn equally from public interest groups (including environmental groups), developers, public officials (including municipal, county, and federal elected officials) and private citizens. The CAC has met several times a year, as documents or products have been generated for review. In addition, public participation was sought at three scoping meetings held for the EIS, and also at a public meeting held in March, 1992. Public comments were incorporated in the DEIS, or otherwise addressed by providing summaries of responses to comments in separate documents. As the components of the DEIS were developed, they were made available to the public by placing the documents in each of five designated repositories. Additional comments have been sought through public hearings and submissions on the EIS.

Preparation of the SAMP

The SAMP was developed in the following sequence: (1.) Definition of the District's needs; (2.) Assessment of the existing wetland functions of the District, and preparation of a map which compared the relative functions of the wetlands with one another; (3.) Development of alternative land-use configurations which would meet the District's projected growth needs and analysis of their impacts; (4.) Establishment of the preferred alternative; (5.) Development of mechanisms to mitigate unavoidable environmental impacts; (6.) Development of products and processes by which the SAMP will be implemented.

The statement of the District's needs was developed by the HMDC in its role as local sponsor for the SAMP, and is included in the SAMP EIS. The needs of the District include two major categories: environmental needs, which include remediation, habitat enhancement and habitat preservation, and development needs, which include residential, commercial, office, industrial, and transportation/infrastructure. This identification of needs arose from the HMDC's unique statutory mandate, and has allowed comprehensive environmental goals to be fully integrated into the land use planning process, rather than being considered in isolation, which is ordinarily the case. The environmental needs of the District, are presented in the SAMP EIS, and a plan for addressing them over the 20-year life of the SAMP is detailed in the Environmental Improvement Program (EIP) which was prepared by the HMDC. The cost of providing for the District's environmental needs, which amounts to approximately 875 million dollars, is shown by category in Figure 1. Approximately 560 million dollars of these costs are not currently funded, and only about 14% of these costs have the potential to be funded from existing programs (HMDC, 1995). Therefore, it would be necessary to provide approximately 480 million dollars to fund these environmental needs. The EIP proposes to address this funding shortfall by a combination of utilizing all existing Federal and State programs as potential funding sources, using a Transfer of Development Rights (TDR) system, and finally, an environmental assessment to be placed on existing and new development to fund the bulk of the improvements. The breakdown of the estimated funding to be derived from these sources is shown in Figure 2.

The development needs of the District were developed by projecting estimates of what the District's share of the regional need for growth would be. Since the SAMP will be a 20-year plan, the projections, which were derived from a number of different sources, were based on the amount of regional growth that the District would absorb over the twenty year time period, when taking into consideration the growth which would be expected to occur in the remainder of the region. The District's needs were accepted for use in preparation of the DEIS at the following values: 14,000 housing units; 18 million square feet (MSF) of primary office space; 2.7 MSF of commercial space; and 16 MSF of warehouse/secondary office space.1

Following the definition of the District's development needs, six different land-use scenarios which would accommodate the projected development were evaluated for impacts. These alternatives were: upland, redevelopment, growth centers, highway corridors, dispersed development, out-of-district development, and no-action, which in this case, was defined as a continuation of the existing Master Plan. None of the alternatives by themselves was found to be acceptable; either it was incapable of supporting all of the projected growth, or else it did not minimize the impacts to wetlands in an acceptable manner. An additional land use alternative was therefore developed by maximizing upland use, incorporating an out-of-district component, and including the lowest impact components of the other alternatives, to the extent necessary to accommodate the projected growth. This alternative, when subjected to detailed environmental evaluation, had the lowest impacts of any of the alternatives and was accepted in the DEIS as the preferred alternative.

The complete proposed SAMP plan includes the following elements: (1.) A Land Use plan, based on the Hybrid alternative, which fulfills the District's growth needs. The Draft plan proposed 2,200 acres of land for development, of which 842 acres are wetlands. (2.) A compensatory mitigation program, which would require the enhancement of over 3,400 acres of existing wetlands in the District, to ensure that no net loss of wildlife habitat, water quality improvement functions, and social significance functions occurs as a result of the proposed wetland loss. (3.) The Environmental Improvement Program, which would provide approximately $875 million of pollution remediation, additional environmental enhancement, and pollution prevention for the District. (4.) Permanent preservation, through zoning and deed restrictions or conservation easements, of the remaining 7,700 acres of wetlands in the District not proposed for development. (5.) A program of Transferrable Development Rights (TDR), which will provide a mechanism for financial compensation of property owners whose land is not proposed for development.

A variety of products are proposed to assist in implementing the SAMP, once the program has been completed. The new Master Plan and the zoning regulations which implement it will be based on the final SAMP, and will undergo an administrative rulemaking process required by the state. Once adopted, the Master Plan will then be submitted to NOAA for review as a change to the New Jersey's Coastal Zone Management Plan (CZMP). As part of the proposed changes in regulations, the aforementioned TDR system is proposed. In addition, the review process for both Federal §404 permits and state permits are proposed to be streamlined to allow for more expeditious review and processing of SAMP-consistent projects. The Federal products include: (1.) a §404 regional general permit, applicable to specific sites within the District where proposed fill is less than fifteen acres, and to transportation projects which propose fill of less than one acre, and (2.) an abbreviated permit process (APP). The New Jersey state permits would undergo review procedures concurrently with Federal applications, and these procedures are designed to increase certainty while decreasing permit process time. Finally, a number of mitigation banks are proposed for the District, which will also contribute to lowered permit processing time, as well as provide opportunities for large-scale habitat improvement. The SAMP, therefore, in its final form, can offer regulatory relief as well as achieving comprehensive protection and environmental improvement to a significant portion of the Hackensack River watershed.

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Watershed Strategy: Managing a Most Valuable Resource

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Introduction

In order to effectively manage a watershed, a strategy which deals with the watershed as a whole rather than individual parts is crucial. A complete watershed strategy incorporates key issues of a particular watershed and may involve the coordination of several different agencies. This approach was utilized in the development of a watershed management plan prepared for the Water Authority of Great Neck North (the Authority), which obtains its water from a limited sole source coastal aquifer system.

Background

The Authority serves public water to the area of the Great Neck Peninsula, Long Island, New York. The total population serviced by the Authority is estimated to be 31,400, distributed among 7,900 service accounts, in an area of approximately 6.4 square miles. To meet its current water demands, the Authority currently pumps an average of 1,555 million gallons per year or 4.26 million gallons per day (MGD). The hydrogeologic setting of the Great Neck Peninsula makes it susceptible to saltwater intrusion, especially with significant pumpage stresses imposed over a relatively small area. Two (2) of the Authority's ten (10) wells have been removed from service as a result of the detection of chloride concentrations in excess of the current EPA Drinking Water Standard of 250 mg/l. The occurrence of saltwater intrusion and the closure of wells has led to water quantity limitations, which need to be addressed on a watershed level.

Watershed Strategy

The development of a watershed strategy involved the coordination of a number of different agencies including the USGS, local public works departments, public water suppliers, and independent consultants. Information from these agencies involved the following:

- Characterization of the hydrogeology of the Authority's watershed,
- Water budget of the aquifer system comprising the Authority's watershed,
- Relationship of public supply well pumpage and chloride concentrations,
- Identification of saltwater wedges beneath the Great Neck Peninsula,
- Saltwater intrusion modeling and fate of saltwater wedges,
- Water conservation efforts.

Preparation of a Watershed Management Plan

Information from the various agencies made up separate components which were incorporated into the watershed management plan prepared for the Authority. The plan assimilated the separate components into a watershed approach designed to mitigate saltwater intrusion through the development of both short and long term operating plans.

Hydrogeology of the Watershed

The hydrogeologic setting of the Great Neck Peninsula is complex and proves sensitive to pumpage stresses primarily due to two highly confined aquifers which abut saltwater. The base of the hydrogeologic setting consists of crystalline bedrock through which there is little or no groundwater flow. The bedrock is overlain by a series of unconsolidated deposits.

Immediately overlying the bedrock is the Raritan formation of Late Cretaceous age which consists of the Lloyd Aquifer confined by the Raritan Clay Member. The Raritan Clay, where it exists, isolates the Lloyd Aquifer from impacts from the overlying aquifers and establishes a conduit from the Lloyd Aquifer to the surrounding saltwater bodies. Currently, five of the Authority's wells are classified as being screened in the Lloyd and approximately 50% of the Authority's total pumpage is from this aquifer.

The Magothy Aquifer is composed of Upper Cretaceous sediments that overlie the Raritan clay. The lower portions of this aquifer exhibits semi-confined characteristics. In the Great Neck Peninsula area, much of the Magothy has been extensively eroded by glacial action and has been completely removed in the northern extent of the Peninsula. Due to its higher hydraulic conductivity, the Magothy Aquifer is more suitable for water supply than the Lloyd Aquifer, where adequate aquifer thicknesses can be found. The remaining three active Authority wells are screened in the Magothy Aquifer.

The Port Washington Aquifer is a sequence of deposits of Pleistocene and/or late Cretaceous age that underlie only the northernmost portions of the Great Neck Peninsula. These deposits form a distinct hydrogeologic unit that rests upon bedrock and is overlain by a confining clay, the Port Washington confining unit (Stumm, 1993). Two of the Authority's wells are screened in the Port Washington Aquifer and have both been lost due to saltwater intrusion. This indicates that the aquifer is very sensitive to pumpage with regard to saltwater and that most of the northern extents of the aquifer are already salty.

The Port Washington confining unit overlies the Port Washington and overlaps the adjacent Cretaceous units. It appears that this confining unit thins out dramatically over the Magothy Aquifer. The Port Washington confining unit confines the water in the underlying aquifers, but the variability of its thickness permits local interchange of water with that of the adjacent aquifers.

The Upper Glacial Aquifer consists of deposits of late Pleistocene and Holocene age that overlie the Magothy Aquifer and the Port Washington confining unit (Kilburn, 1979). The Upper Glacial Aquifer is the water table aquifer on the Peninsula and transmits recharge to the underlying aquifers but is not being utilized as a source of supply due to its proximity to the land surface and contamination.

Water Budget of the Aquifer System

The hydrogeology of the watershed was used to determine the Authority's water budget and permissive sustained yield of associated aquifers. The water budget identified inflows and outflows from the watershed for each aquifer in order to determine the bounds of the water resources and was calculated for the Authority using published groundwater levels throughout the Great Neck Peninsula. Inflows are limited to recharge over the entire area from rainfall and groundwater underflow across the southern boundary of the Authority. Outflows are groundwater underflow to surface water, stream flow fed by groundwater and water removed by pumpage. The water budget determined that the watersheds outflow exceeds inflow, particularly in the lower confined aquifers. This is enhanced by the existence of the Port Washington and Raritan Clay confining units which retard and prevent recharge from reaching the underlying aquifers. Particularly vulnerable are the Lloyd and Port Washington Aquifers, which are hydraulically connected and significantly confined. Resulting from this, is the displacement of freshwater by saltwater from the surrounding bodies of water which is mostly taking place in the Port Washington Aquifer and areas of the Lloyd Aquifer exposed to saltwater.

From the water budget, the permissive sustained yield for the aquifer system indicated that existing Lloyd pumpage exceeded the calculated recharge resulting in saltwater intrusion. Conditions significantly differ in the overlying aquifers, which are subject to direct recharge and greater underflow from the south.

Relationship of Public Supply Well Pumpage and Chloride Concentrations

In order to determine the Authority wells most susceptible to saltwater intrusion, chloride concentrations in the wells versus pumpage over time was studied. The study showed that, in general, both Magothy and Lloyd screened wells showed increasing chloride levels with increased pumpage. The increasing chloride levels in the Magothy wells was attributed to their increased utilization in an attempt to shift pumpage out of the Lloyd and their proximity to surrounding surface water. As suspected, the relationship of pumpage and increasing chloride concentrations was much more pronounced in the Lloyd screened wells. Chloride concentrations were also considerably greater in these wells. Sensitivity to saltwater intrusion was characteristic of location (proximity to surface water and Port Washington Aquifer) and the general overdraft of the Lloyd. Wells where a strong relationship between chloride concentrations and pumpage does not exist, are generally located in buffered central locations of the Great Neck Peninsula.

Identification of Saltwater Wedges Beneath the Great Neck Peninsula

The USGS in cooperation with the NCDPW conducted a groundwater quality project to identify saltwater wedges beneath the Peninsula. As part of the project, the USGS and NCDPW installed groundwater monitoring wells throughout the Peninsula. Core samples collected during drilling were used to better define the local geology. Additionally, the monitoring wells installed were logged using gamma radiation to better define the geology and focused electromagnetic-induction to delineate the saltwater-freshwater interface. Results of the geophysical testing were correlated to core samples, filter press samples and groundwater samples so that accurate assumptions related to saltwater intrusion were obtained (Stumm, 1993). The USGS & NCDPW program identified two wedge-shaped areas of saltwater in the northern part of Great Neck; one at the base of the Port Washington Aquifer in the extreme northern tip of the Peninsula and the second at the base of the Lloyd Aquifer.

Saltwater Intrusion Modeling

Incorporating information obtained from their drilling project, the NCDPW performed, in conjunction with Camp Dresser & McKee (CDM), saltwater intrusion modeling for the Great Neck Peninsula and its relationship to Authority pumpage. The NCDPW groundwater model depicts both current and projected positions of the saltwater interface as well as freshwater heads for the Lloyd Aquifer. Currently, the model depicts significant cones of depression consisting of negative freshwater heads surrounding the Authority's Lloyd wells under their typical operating conditions. The saltwater intrusion model projections are approximate due to how the model interprets saltwater conditions (chloride concentrations greater than 10,000 ppm) and transition conditions (chloride concentrations less than 1,000 ppm). Modeling focused on the redistribution of Lloyd pumpage to various locations further south both within the Authority's service area and a neighboring water district less susceptible to saltwater intrusion. Redistribution of pumpage to the neighboring water district was accomplished by the projection of new well(s) screened in the Lloyd Aquifer. By redistributing pumpage of Lloyd wells most vulnerable to saltwater intrusion to existing wells within the Authority's boundaries, an attempt was made to produce a pumpage scenario that mitigates saltwater intrusion. Consideration was also given to avoiding corridors of low heads in the Lloyd Aquifer leading from the bays to the new wells.

General conclusions, based on the above model simulations, confirmed that public supply well pumping out of the Lloyd Aquifer in the Authority's service area will lead to some degree of saltwater intrusion and that pumpage should be shifted to aquifers where recharge rates exceed withdrawal rates. Additional conclusions addressed locations of a new Lloyd public supply well which, according to modeling results, would not be affected by saltwater intrusion before the year 2100 and a location beyond the impact of saltwater intrusion. Redistribution of pumpage of existing Lloyd wells based on a priority basis developed by CDM had insignificant effects on saltwater intrusion.

Water Conservation Efforts

In order to conserve water, numerous conservation efforts were undertaken by the Authority. To discourage the overuse of water, a water conservation rate structure was adopted. Also adopted by the Authority, in addition to lawn sprinkling regulations, were the use of raingauges and moisture sensors on automatic sprinkler systems. Other conservation efforts include a pilot leak detection survey to locate unaccounted for water due to leakage, water audits for the greatest water uses, and a retrofit program.

Assimilation of Components

The coordination of the above information made it possible to approach the Authority's problem on a watershed level. Using this information, P.W. Grosser Consulting developed pumpage scenarios designed to bracket various conditions ranging from restructuring the pumping of the Authority's existing wells to locating up to 2.54 MGD off of the Great Neck Peninsula. The latter focused on replacing all existing Lloyd pumpage located on the Peninsula. Pumpage scenarios were based on yearly water pumpage data compiled by the Authority for the most recent 5 year period. The 5 year average pumpage of the Authority is approximately 4.26 MGD, of which 2.54 MGD is from the Lloyd Aquifer. Currently, the remaining pumpage is from the Magothy Aquifer.

A total of five pumpage scenarios were developed for modeling by NCDPW which were divided into summer and winter average pumpages in order to represent typical annual water usage. On one side of the spectrum, a pumpage scenario was developed using existing wells only. This scenario concentrated on transferring the majority of pumpage to the Magothy Aquifer and attempts to provide an optimum pumpage plan using the Authority's current capacity. The other side of the spectrum replaced all existing Lloyd Pumpage from the Great Neck Peninsula (2.54 MGD) with proposed wells located off of the Peninsula. This model scenario utilized wells screened in Magothy or reworked Magothy/Pliestocene material. The remaining pumpage scenarios replaced varying amounts of Lloyd pumpage with wells located off of the Peninsula, including pumpage equal to and two times the permissive sustained yield of the Lloyd Aquifer. Additional pumpage needs were met by existing wells pumped on a priority basis.

The results of the model simulations varied from continued saltwater intrusion and the impact of all existing Lloyd wells by the year 2093 in the first scenario to no Lloyd wells being impacted. The latter scenario represents all existing Lloyd pumpage shifted off of the Peninsula resulting in an actual retreat of the saltwater interface of approximately 10 feet per year. As expected, results of the remaining simulations varied between the above scenarios. If a particular well proved sensitive to pumpage in one of these scenarios, causing it to be lost to saltwater intrusion, it was rerun with an alternate well. The model results indicated particular wells that could be utilized for significant periods of time without impact, as well as ones that were impacted with relatively low capacity pumping and influence of other wells. Selected Lloyd pumpage on the Great Neck Peninsula at a rate equal to the approximate sustained yield of the Lloyd Aquifer is possible if it is properly distributed among the existing Lloyd wells.

With the information gained from the modeling, both short and long term operating plans were developed for the Authority. Short term operating plans include shifting pumpage from the Lloyd Aquifer in an attempt to reduce the impact of saltwater intrusion. Due to mitigating factors such as maintenance problems causing wells to be shut down, current actual well capacity, and system pressure demands which cause certain wells to be pumped during peak times, it was best to provide a priority basis for well pumpage rather then set a rigid pumpage guideline.

It was evident through the study of the hydrogeologic conditions existing beneath the Authority's service area and the subsequent groundwater model results, that the development of new sources of supply outside of the Authority's service area is necessary to preclude the loss of additional wells to saltwater intrusion. The long term operating plan includes the development of new sources, screened in the Magothy or reworked Magothy/Pliestocene material. These wells have to be pumped on a high priority basis, with existing Magothy wells making up the bulk of the Authority's water demand. The plan specifies, that once the proposed wells are installed and operating, Lloyd pumpage from the Great Neck Peninsula should not exceed the permissive sustained yield at any given time.

Summary and Conclusions

The development of a watershed management plan for a limited coastal aquifer system impacted by saltwater intrusion involved the coordination of a number of different agencies. It is the ability to utilize large quantities of available information and resources at ones disposal that makes solving problems on a watershed level possible.

Coastal America: A Partnership Paradigm for Protecting and Restoring Ecosystems and Watersheds

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Introduction

The Coastal America partnership provides a process for dealing with coastal resource issues on a watershed basis. The Coastal America process is structured to address the whole spectrum of activity and resource use throughout a given watershed. The result of this process is corrective actions, such as "shovel in the ground" projects at the local level. Traditional environmental protection activities that do not consider the entire drainage area of a coastal region cannot successfully restore or protect a coastal ecosystem from the impacts of region wide activities.

The purpose of Coastal America as stated in the interagency memorandum of understanding that established the partnership, is to protect, preserve, and restore the Nation's coastal ecosystems through regional activities that provide direct local watershed action. This innovative action-oriented initiative is a true partnership process, not a program. The federal partners include those agencies with principal responsibility for the stewardship of coastal resources, those with responsibility for infrastructure development, and those whose activities impact coastal environments (Departments of Agriculture, Air Force, Army, Commerce, Defense, Energy, Housing and Urban Development, Interior, Navy, Transportation, the Environmental Protection Agency and the Executive Office of the President). The partnership integrates the capabilities and existing resources of the federal agencies with state, local and non-governmental efforts to address specific problems, by sharing information, pooling resources and combining management skills and technical expertise.

The Coastal America collaborative problem-solving structure enables national policy issues to be identified and resolved, regional strategies to be developed and local projects to be implemented. At the national level, policy issues are addressed by a Principals Group comprised of Under Secretaries and Assistant Secretaries, and a national team comprised of senior level representatives from the federal partner agencies. At the regional level, interagency teams identify specific problems and geographic areas of concern in an ecosystem/watershed context. At the local level, projects are implemented by pooling resources and expertise.

National Level

At the national level, the Coastal America federal agencies have all supported or administered some type of watershed protection or management planning. Often their efforts require active participation by a range of parties with an interest in the resource issues being addressed. Coastal America provides a framework for federal agencies to work as a team with state and local agencies, and non-governmental organizations to resolve such issues. Resolution of a coastal resource issue may even involve modifying policy. For example, to encourage beneficial use of dredge material for wetlands restoration, the Principals introduced modifications to federal laws and policies. In the San Francisco Bay, this enabled the use of clean dredge material from the Petaluma River and the Oakland Harbor to establish 350 acres of salt marsh on diked agricultural land.

In addition to looking at issues preventing the partnership from addressing a concern, the Principals and national team also develop consensus reports to promote a watershed management approach. An example of a consensus report is "Toward a Watershed Approach: A Framework for Aquatic Ecosystem Restoration, Protection, and Management." This report on aquatic ecosystem protection and restoration through watershed-based resource management approaches has two underlying themes. They are: (l) aquatic ecosystems, which are intrinsically related to the hydro geologic characteristics of watersheds, are most effectively addressed in a watershed context; and (2) truly comprehensive watershed approaches can only succeed with the collaboration and cooperation of the full range of parties with jurisdiction over, and interest in, the resources at stake. This holistic approach is central to the Coastal America philosophy and ingrained at the regional and local levels. In fact, Coastal America's strength is the creativity and wholeness of the projects that are developed within an ecosystem framework through its collaborative partnership process.

Regional Level

Coastal America has nine regions that implement their efforts in a watershed context. Every region has a team that consists of senior regional representatives of the partnership agencies. These teams are designated Regional Implementation Teams (RITs). Each team establishes a process and a strategy for achieving its coastal restoration and protection goals and objectives, based on the watershed approach. All potential Coastal America projects in a region are introduced to the RIT by their lead agency: i.e., that agency on the RIT with the primary responsibility to assist other federal agencies; state, local and tribal governments; non-governmental organizations or the private sector in the implementation of the watershed or sub-watershed project.

For example, the focus of the Northeast RIT is to examine the region's remaining significant ecosystems, particularly the temperate coastal salt marsh and estuarine habitats, and to ensure their viability over the next several decades. The Northeast regional team has concentrated on two problem areas identified for priority action-the restoration of wetlands and mitigation of contaminated sediments in aquatic sites. The other eight RITs operate in a similar manner with appropriate modifications in their process and priorities. In the Southeast region, a leadership group of the regional principals provides guidance to the members of the RIT. This leadership group is comprised of regional administrators who report to national headquarters. It should also be noted that as the "front line" administrators of most pollution control and coastal protection plans, several coastal states are now realigning their water quality programs along watershed boundaries.

Local Level

Local project teams have been very effective at helping to restore watersheds. Individual, site specific local projects are developed within a watershed/ecosystem framework and proposed to the Coastal America regional teams. Each region maintains and regularly updates a working list of endorsed local projects. Federal and non-federal resources and expertise are then pooled and leveraged for project implementation. Specific projects within a watershed are integrated to provide a comprehensive approach.

An example of this watershed approach is the Blackstone River Project in the Northeast. Recognizing that the problems of the river are highly interrelated, the National Park Service, which manages this National Heritage Corridor, requested that the Coastal America partnership provide assistance to its watershed restoration efforts. The project integrates individual efforts such as shore stabilization, contaminated sediment remediation, and mitigation of obstructions to anadromous fish passage to ensure effective restoration of the river.

In the Southeast, we are restoring access to historic anadromous fish spawning habitat in the Albemarle-Pamlico Sound watershed through the removal of dams and the construction of fish passages. Coastal America partners are providing essential dollars and services for action. More importantly, the partnership is facilitating an interagency consensus and establishing an institutional framework for future cooperative efforts. Non-federal partners include the State of North Carolina's Environment, Health and Natural Resources Department and Transportation Department; the North Carolina Wildlife Resources Commission; the Virginia Division of Game and Inland Fisheries; and the Virginia Council on the Environment.

In the Northwest, federal and state agencies and the Port of Seattle have undertaken several habitat restoration projects along the Duwamish River through the Coastal America partnership. This project in Seattle, Washington, will increase the quantity and quality of habitat for fish and wildlife species, while allowing for assessment of various restoration techniques. The project has also increased our understanding of habitat restoration in an urban watershed. The collaborative Coastal America process, which includes the agencies with jurisdiction over infrastructure development and maintenance, has been essential to the overall success of this restoration effort.

A final example of a local project effort is the Maumee Nonpoint Source Pilot Project which affects the Great Lakes. This is a tri-state effort for a 6,586 square mile watershed. This demonstration project is designed to determine the feasibility of prescriptive fertilizer application by farmers to reduce nonpoint source pollution to Lake Erie. It is estimated that 65 percent of the phosphorus loading to the Maumee River originates from runoff from over fertilized, unprotected cropland exposed to winter rains and snows. Through this partnership effort, farmers in the watershed are now reducing fertilizer applications and, thereby, minimizing nutrient runoff into the river.

Future Directions

The Coastal America partnership process encourages environmental restoration and protection while enabling and enhancing economic development. This concept of sustainable development is now incorporated in our national policies, regional plans, and local projects. At the national level, the 1994 Memorandum of Understanding commits the partners to a "national effort which is guided by the concepts of ecosystem management and sustainable development." At the regional level, the strategies developed by the regional teams identify specific problems and geographic areas of concern within the context of sustainable development and ecosystem management objectives. At the local level, action-oriented projects make these concepts a reality.

Recognizing that a watershed approach provides the most effective framework for aquatic ecosystem restoration and protection, the Principals have directed the Partnership to focus on "activities that provide direct local and watershed action." Since Coastal America includes the full spectrum of federal and state natural resource and economic development agencies, local organizations, private industry and public interest groups, the partnership can formulate comprehensive solutions in a system-wide context. It can provide a collaborative problem solving process that brings the stakeholders to the table to resolve the problems that threaten a watershed's aquatic resources.

The Coastal America partnership will continue to address many of the problems facing our Nation's coastal environment from this new perspective. The future of our aquatic ecosystems and the fish and wildlife that depend on them lies in integrated and collaborative decision-making on a watershed basis in an ecosystem context. By these means we can protect and support clean, abundant habitats and water resources, healthy ecosystems, and continued use of our waterways for our economic and environmental benefit.

New York City's Watershed Protection Program

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Introduction

This paper is focused on exploring the accomplishments of the last decade in protecting in New York City's watershed environment. The recent pace of program enhancement has been extremely rapid, especially since work on the watershed program began (in 1988). Since then, DEP has received 3 filtration avoidance determinations, with a fourth to be issued shortly; been involved with 5 expert panels; prepared 5 environmental impact statements, the Agency has been under the direction of three different City Administrations, and has been through approximately 10 rewrites of the Watershed Rules and Regulations. The Division of Drinking Water Quality Control has increased in staff from 60 to 280 people and its expense budget has increased 8-fold. It's been an dynamic period that can be characterized by a number of significant accomplishments, and these will be described below in terms of two components:

1. The evolution of the City's watershed protection program, and the basic technical concepts underlying its design;
2. The formulation and key elements of the City's current watershed protection program, and some of the recent accomplishments that have occurred as a result of recent City initiatives.

System Description

New York City's drinking water is renowned for its purity and good taste. The excellent quality of the City's drinking water can be directly attributed to the size, configuration, and operational flexibility of the system, coupled with the natural characteristics of the water supply watersheds. The City's water supply is comprised of three systems, the Croton, the Catskill, and the Delaware. The watershed area of the three systems combined covers 2,000 square miles across eight counties and 60 towns. The system has a total usable capacity, when full, of approximately 550 billion gallons stored in 19 reservoirs and three controlled lakes.

Evolution of the Watershed Program

The evolution of the City's watershed program has been shaped by three items:

1. The influence of the Clean Water Act upon the formulation of City source water protection initiatives,
2. The influence of the Safe Drinking Water Act upon the formulation of City source water protection initiatives.
3. The City's adoption of the Ecosystem Approach to watershed management as the underlying scientific concept behind it's current source water protection programs.

Clean Water Act

Earlier versions of the Act concentrated on the control of point source pollution. It was soon discovered that the serious pollution threatening lakes and reservoirs arose from land areas of intense agricultural and urban land use_mainly from phosphorus, sediment, and pesticides. After 15 years of nonpoint pollution planning, study, and problem identification, the Clean Water Act was revised in 1987 thus containing provisions which moved to control nonpoint pollution, and take more of a watershed approach toward water quality management.

Safe Drinking Water Act

Prior to the passage of the Safe Drinking Water Act Amendments of 1986, previous versions of the Act (1914, 1925, 1942, 1946, 1962, 1974) primarily focused on water quality standards measured at the tap. The quality of untreated source water received little attention. The 1986 amendments, in particular the Surface Water Treatment Rule, had a profound effect on source protection efforts. In fact, the SDWA Amendments of 1986 were the motivating force behind many watershed protection initiatives nationwide, including the City's. For the first time attention was being focused on the quality of drinking water supply source waters.

Prior to the strengthening of the Clean Water Act in the late 1970's, the City, like many other water suppliers, used chemical treatment, i.e, chlorine, and copper sulfate to maintain quality in its source waters. The tightening of Clean Water Act standards greatly reduced the City ability to employ this practice. Concern for the reservoir ecosystem was heightened, and chemical treatment had to be used sparingly. This made it that much more important for the City to design and implement a watershed protection program that focused on identifying and controlling the sources of pollution within its watershed basins rather than the treatment of the effects of the pollution after it had already entered the water supply. It also made it more important for those managing the supply to have a better understanding of the chemical, physical, and biological processes occurring in the reservoirs and their drainage basins, particularly from an ecological perspective. The establishment of an ecosystem approach to watershed water quality management became necessary.

Ecosystem Approach to Watershed Management

As such, based on work of Likens and Boorman which began in 1963 at the Hubbard Brook Watershed in New Hampshire, DEP, in the early 1980's, employed a Watershed Approach which focused on water quality management from a drainage basin perspective. This approach was based on the principle that water quality assessments of lakes and reservoirs can best be accomplished when approached from a watershed, or regional perspective. As such, DEP modified its traditional watershed monitoring program from one which had focused primarily on water quality information collected at aqueduct and tunnel influent and effluent points, and sewage treatment plant discharges, to a broader program including limnological or reservoir, and hydrological or tributary data collection.

Elements of the Watershed Protection Program

To address the broader program, DEP greatly enhanced its monitoring efforts. All four of the City's watershed monitoring laboratories were upgraded with state-of-the-art equipment at a capital cost of ten million dollars. In addition, watershed staffing was greatly increased. And lastly, geographic information system (GIS) was created to provide support in the various program areas.

After characterizing the reservoirs and their watersheds with baseline information, and identifying and evaluating pollution sources, the City's watershed protection program was formulated. It consists of five principal elements:

1. New watershed regulations and enforcement.
2. Capital improvements of sewage treatment plants.
3. Acquisition of sensitive watershed land.
4. Partnerships with watershed communities.
5. Research and surveillance of waterborne disease from source to tap, that are described below.

1. New Watershed Regulations and Enforcement

As a key element of New York City's protection effort, DEP revised and modernized the watershed regulations of 1953. The new regulations have been designed to curb the loadings of phosphorus, coliform bacteria, and other contaminants into the watersheds, and govern a range of activities in the watershed, such as the design and siting of sewage treatment plants, septic systems, and stormwater management facilities, as well as the construction of impervious surfaces, such as buildings and parking lots. New surface water discharges from wastewater treatment plants will be prohibited within 60 day travel time to water supply intakes, or in coliform restricted basins, and a limited number of "pilot" wastewater treatment plants may be built in phosphorus restricted basins in the next 5 years, provided a 3:1 phosphorus offset can be provided, and the plant can meet an effluent limit of 0.2 mg/l. A phosphorus restricted basin is one in which the threshold concentration for phosphorus is being exceeded, and is thus experiencing water quality degradation. In addition, the regulations require the installation of advanced sewage treatment equipment on all discharges in the watershed.

2. Capital Improvements to Sewage Treatment Plants

Another significant component of DEP's program is the upgrading of all sewage treatment plants in the watershed. Currently, 104 treatment facilities operate in the watershed with a total discharge of 10.9 million gallons a day. The City will move forward with its plan to spend 200 million dollars to upgrade all nine City-owned upstate wastewater treatment plants. 50 million dollars will be spent to bring all other public and private wastewater treatment plants in the watershed to tertiary treatment;and 240 million will be spent to upgrade City-owned facilities and dams in the watershed.

3. Land Acquisition Program

Land acquisition is another important element of the watershed protection program. Although the City's watershed area spans 2000 square miles, the City currently owns only about 2% of that land, or 85,000 acres. The City will buy undeveloped land identified as most important to protect water quality. At the conclusion of the program, it is anticipated NYC's land holdings in the watershed will triple. The City's acquisition program will concentrate on watershed properties in close proximity to reservoir intakes, land in flood plains and alongside rivers and streams, land containing wetlands and land with moderate slopes. The City will commit 250 million dollars over 15 years to buy land in the Catskill and Delaware System Watersheds, and 10 million dollars to purchase land in the Croton Watershed. The State will also contribute funds to the acquisition effort.

4. Partnerships with Watershed Communities

To enhance the effectiveness of regulation, enforcement, and land acquisition, the City has worked closely with interest groups and local, county, state, and federal officials to develop partnerships with watershed communities.

The Watershed Agricultural Program is the first cooperative effort that has been implemented. Since agriculture is important to watershed economies, DEP established a joint upstate/downstate task force to study the problems of maintaining viable farms while reducing agricultural pollution. The task force developed a program, known as Whole Farm Planning, which uses best management practices to prevent or dramatically curtail pollution from each dairy or livestock farm. Phase I of the program established 10 pilot farms. In October 1994 the Watershed Agricultural Council commenced work under its 5-year, $35.2 million Phase II program. Fifty new farms came into the program by the end of 1994, and as of

October of 1995 160 farms have signed onto the program. Although it is a volunteer program, it is highly likely that at least 85% of watershed farmers will be participating by the end of 1997.

In addition to the Watershed Agricultural Program, the recently announced watershed agreement of November 1995, includes a series of innovative partnership programs designed to facilitate local management in watershed communities and to promote environmentally sensible economic development. The City will fund approximately 350 million dollars in water quality and partnership programs both east and west of the Hudson River. Some notable aspects of the partnership program include: the formation of a watershed partnership council, the establishment of a water quality investment program, and planned partnership initiatives.

5. Research & Surveillance of Waterborne Disease from Source to Tap

Pathogens, or disease causing organisms, are the driving force behind the Surface Water Treatment Rule. Independently and in partnership with Cornell University and the New York State Department of Health, DEP has developed a broad range of studies to investigate the source, transport and fate of pathogens in the watershed. Specific studies include monitoring for viruses, Cryptosporidium and Giardia at farms, sewage plants and watershed locations. Additionally, DEP and the New York City Dept. of Health have established a disease surveillance unit that tracks the incidence of giardiasis and cryptosporidiosis in the City. Preliminary findings suggest that incidence of such diseases is well below national averages and causation does not appear to be related to City water.

Accomplishments

Although there have been many accomplishments over the last five years concerning the City's Watershed Protection Program, two are considered to be highly significant. These are the Watershed Agreement of November 1995 and the Kensico Water Pollution Control Plan.

The Watershed Agreement of November 1995

This agreement will help guarantee the superior quality of the City's drinking water into the next century. Most significantly, the State will now issue the City a permit so it can more forward with its watershed land purchases. The State will formally adopt the City's new watershed rules and regulations, and as mentioned earlier the agreement provides a mechanism by which upstate and downstate stakeholders can work together on mutually beneficial water pollution control programs. In addition, EPA has agreed to extend the City's filtration waiver to December 1999.

The Kensico Reservoir Water Pollution Control Plan (Hillview)

Of all the water bodies in the City's watersheds, none is as important as the Kensico Reservoir in

Westchester County. Ninety percent of all the water that flows to the City from the upstate watersheds runs through this reservoir. An analysis of water quality data at Kensico Reservoir revealed peaks of fecal coliform bacteria during the late fall early winter period. A two year study of the Kensico Basin indicated that increased populations of waterfowl and ring-billed gulls were the cause of the seasonal coliform problem. Because of the coliform concentrations and the risk of losing filtration avoidance, the City bypassed Kensico Reservoir during the late fall and early winter of 1991, 1992, and 1993. In late 1993, the City implemented a waterfowl control program which was highly effective in reducing the numbers of waterfowl and gulls, as a result the coliform bacteria numbers dropped as well. Accordingly, the City has not bypassed Kensico Reservoir in 1994, and 1995, and compliance with the fecal coliform criteria of the Surface Water Treatment Rule has been exceptional. A similar program was instituted at Hillview Reservoir in Yonkers last summer, and was highly effective. Both the Kensico and Hillview examples illustrate the importance of using applied research in developing pollution control strategies.

Objectives and Examples from a Comprehensive Water Quality Monitoring Program

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Web Note: *Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

The water quality monitoring program of the New York City (NYC) water supply was designed to meet multiple objectives. A comprehensive watershed-wide sampling program carried out by the NYC Department of Environmental Protection (DEP) provides data to meet both short-term and long-term management needs. NYC's water supply is an unfiltered surface water supply that serves nine million residents of NYC and nine upstate counties, and considerable effort and resources are devoted to the protection and preservation of raw water quality. A large field and laboratory staff of 300 professionals is committed to the task of ensuring that water sampling and analysis is carried out competently and efficiently. A multidisciplinary approach is taken to meet the challenges of managing the vital resource of the NYC water supply. Scientists in the fields of chemistry, limnology, hydrology, and microbiology are among the professionals that contribute to the knowledge base that is used to make management decisions.

Monitoring water quality in reservoirs and their watersheds is of critical importance in complying with federal and state water quality criteria, and in documenting trends in water quality. A commitment to an extensive monitoring program that not only targets meeting established standards, but provides information on whether antidegradation goals are met has been expanded in recent years.

NYC water quality monitoring objectives include regulatory compliance monitoring, tracking and control of treatment processes, evaluation of the efficacy of watershed protection, characterization of ambient conditions, identification and tracking of episodic problems, and identification of problems that may potentially degrade overall water quality. Assessment of concerns such as eutrophication, along with assessment of remedial measures used to improve water quality, are also addressed through water quality monitoring. Data are also used in the development and validation of water quality models. Progressive technologies, such as Geographic Information Systems (GIS) are used as tools in the modeling process and in the characterization of water quality and associated landscape attributes such as soils and land use.

The total NYC water supply watershed area covers nearly 4970 km2 (1950 mi2) and encompasses 19 reservoirs and three controlled lakes. The watersheds that contribute to the source waters, Kensico and New Croton Reservoirs, are divided into three systems: the Catskill, Delaware and Croton systems (Figure 1). The Catskill system has two collecting reservoirs: the Ashokan and Schoharie Reservoirs, which were completed in 1917 and 1927, respectively. The Catskill system has a maximum storage capacity of 562x106m3 (148 billion gallons (BG)), and drains an area of 1443 km2 (555 mi2). The Delaware system is the newest and largest of the three systems, and was completed in 1965. Its four reservoirs include the Rondout (on-line in 1944), Neversink (1953), Pepacton (1955), and Cannonsville (1965), which collectively store 1239x106m3 (326 BG), and drain an area of 2569 km2 (988 mi2). The Croton system is the oldest system, and supplies 10-15% of the annual water that is delivered to distribution. The Croton system has 12 reservoirs and 3 controlled lakes that drain a total area of 932 km2 (375 mi2) and their collective capacity is approximately 330.6x106m3 (87 BG).

Several internal DEP reports document the scope of water quality monitoring in the watersheds and reservoirs preceding the distribution system (e.g., NYCDEP, 1993a and NYCDEP, 1993b). A separate monitoring regime applies to the distribution system. The emphasis for this paper will be on the approach to sampling in the watersheds prior to conveyance of water to the terminal source water reservoirs. Compliance monitoring required under the Surface Water Treatment Rule of the Safe Drinking Water Act and other regulatory monitoring, including the monitoring of wastewater treatment plants to determine compliance with State Pollution Discharge Elimination System (SPDES) permits is also covered in these reports.

Inflows and outflows to all reservoirs are monitored, as well as multiple sites within reservoirs and tributary streams. Some system-wide generalizations about hydrological monitoring are presented here to exemplify NYC's watershed sampling strategies.

Watershed processes are dynamic, and it is therefore necessary to sample at a variety of scales, both in space and time. An extensive sampling network is employed at fixed-frequency sampling intervals to characterize annual and seasonal trends in stream water quality. Perennial streams that sustain base flows throughout the year are sampled using periodic grab samples. Sanders et al. (1983) suggest that six samples per year is a rough guideline for the minimum acceptable frequency for most purposes to characterize water quality variables that have an annual cycle. Parameters that are routinely monitored in perennial streams include: physical variables (alkalinity, turbidity, color, temperature, specific conductance, dissolved oxygen; biological variables (total and fecal coliform bacteria; enteric viruses and pathogens), water chemistry variables (nitrate-N, ammonia-N, total phosphorus, total organic carbon, silica, chloride, major cations and trace metals). A special effort by DEP to monitor pathogens is presented by Stern (1996).

Extensive sampling is performed at a variety of scales to track specific problems such as turbidity. In the Catskill system, a "synoptic" approach to evaluating turbidity has been taken, and over a three-year period, over 10,000 grab samples were collected to develop a regional picture of turbidity. Concentration of suspended solids was also determined in conjunction with stream discharge, to make estimates of sediment loads feasible. Using this approach, and limiting sample analysis to two laboratory-derived variables (turbidity and total suspended solids), a large area (over 500 mi2) was sampled to characterize turbidity. Sampling intensity was greatest during Spring and Fall periods of peak runoff to identify any sites with chronic turbidity problems.

Another form of sampling that is employed in watershed streams is intensive storm event monitoring. Where the objective of water quality monitoring is to determine contaminant loadings to reservoirs, storm hydrograph monitoring is essential. Although storm events represent a small percentage of the time, they represent a greater proportion of the substance load, since concentration of many substances is flow-dependent (Ward and Elliot, 1995). Samples are collected using automated samplers or as grab samples, with synchronous flow measurements or records of stream stage used to determine concentration-flow relationships. The method of sample collection is determined by the sampling objectives and size of the study area. For example, in a study of nutrients and related water chemistry in an agricultural watershed of the Delaware system, an automatic pump sampler was used to collect samples at timed intervals during rain events of varying magnitudes and durations. These data were collected over a one-year period for the purpose of validating estimates made using the Generalized Watershed Loading Function (GWLF) model. In conjunction with turbidity studies in the Catskill system, grab samples were collected throughout the storm hydrograph to further examine the patterns in variability and subbasin response to storm events that exceed one-inch of rainfall. In this turbidity study, three different approaches are used to monitor turbidity patterns: fixed frequency sampling; synoptic surveys; and storm event sampling.

Sampling efforts in the watersheds contributing to the NYC water supply consist of a core of fixed frequency sampling stations that have been maintained for many years. In some cases, the water chemistry of the major inflows to the reservoirs have a period of record of 50 years or more, and in recent years, a broader watershed-wide sampling network has been employed. Refinement of sampling strategies began in 1985 and continue today to meet the objectives of detecting problems, documenting change and variability, and providing a vigilant view of this vast and precious water resource.

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The NYC Water Quality Division Geographical Information System (GIS) and Its Applications for The Watershed Management

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Introduction

A Geographical Information System (GIS) is a computerized system for storage, display and manipulation of geographical data. One of the main advantages of the system is its ability to handle different data formats and scales. Therefore a GIS can provide relatively easy access and extraction of information, including map production and table generation. Within the Division of Water Quality Control (DWQC), a GIS is being used for the two main tasks: water quality management strategy development and map production routines. ARC/INFO software, developed by Environmental Systems Research Institute (ESRI) is the primary software used. ARC/INFO allowes storage of GIS data and easy acquisition of different data in various formats.

Database Development

Current data acquisition through GIS import/export capabilities has allowed gathering and storage of such different data sets as scanned images, digital graphic files (DLG) from USGS and National Wetlands Inventory (NWI), survey data, vector and raster data from other GIS packages as well as global positioning system (GPS) data, that support both water quality management strategy development and map production.

Data acquisition is an important part of building a GIS database. Within DWQC data development supports different projects and scientific research. There are three main scales of data: 250K, 100K and 24K. The most commonly used are 24K data because of the best available resolution and ability to match United States Geological Survey (USGS) quadrangles (7.5 minutes quads). The whole New York City watershed area is covered by 68 USGS quads and each quad can contain up to 20 megabytes of digital data (excluding remote sensing data).

GIS data in ARC/INFO format are stored in one location on the main data server. This location is linked with all workstations and shared across the network. This location consists of 11 thematic sub-directories such as 'hydrology', 'soils', etc. All thematic subdirectories contain ARC/INFO GIS layers (coverages) with corresponding metadata text files. Metadata files allow users to see necessary documentation for the coverages. These files can be viewed through the file manager utilities, copied, imported into any wordprocessing software or printed. Typical content of the metadata has information on the date of the coverage creation, method, author, coordinate system, scale, database dictionary, etc.

All GIS data are managed by one person from the GIS group and can not be altered by other users. All new data must pass strict quality control and accuracy assessment through developed customized tools. These tools check topological errors (usually as a result of incorrect digitizing or data transformation) and attribute errors in the database (missed values or wrong value types, i.e., numerical values vs. characters).

Map Production

Map production is a vital part of the watershed management. Among the main mapping requirements is standardization of display and hardcopy output of map features. The speed of the map production depends on the database design. GIS allows storage of many attributes describing spatial features as is necessary to satisfy the subsequent selection and symbolization process. Analytical maps were designed to display results of the data analysis on the map as pie charts or bar diagrams. With a new product of ESRI_Arcview2, this process became much easier. At the same time DWQC utilizes a customized mapping interface named "MapMaker". This was developed by staff and is based on ARC/INFO macro-language (AML). "MapMaker" is linked with the central GIS database and mainly used for production of black and white maps for different reports. Both Arcview2 and "MapMaker" can be linked with other customized applications and programs, developed in ARC/INFO.

The advantage of using customized map making tools for large organizations such as DWQC is an ability to standardize map layouts and map symbols. Many employees with no experience in cartography are able to automatically place labels and other map attributes on a layout without having to choose the correct font, size or style. Maps produced this way look similar and are easily coordinated with other maps for report production.

Water Quality Management

Water quality management strategies need to be developed and supported with environmental models.

The basic factors involved include stream locations, landuse, soil, geology as well as climatic and water quality parameters. The main role of GIS is integration of different layers of information for model input. There are also built-in GIS functions which allow the user to model surfaces and create watershed boundaries. Practical implementation of GIS for watershed management practices was done through the Reckhow phosphorus loading model. This lumped parameter model was fully programmed within ARC/INFO.

The Reckhow method to estimate the phosphorus loads is based on the concept that export coefficients are transferable and that two watersheds in the same region and with similar landuse patterns and geology will contribute the same loading of phosphorus per unit area. Estimates of the total annual mass of phosphorus entering a reservoir or lake is obtained by identifying landuse, applying export coefficients, then summing the annual phosphorus contribution for each nonpoint and point source within the watershed. By changing the assumptions on landuse and export coefficients, it is possible to evaluate the effects of future landuse changes on nutrient loadings, and subsequently water quality. The Reckhow model utilizes export coefficients that are calculated from hydrological flow and stream nutrient concentrations. Flow and concentration measurements are converted to total mass loadings. Mass loadings are then divided by sub-basin areas to calculate export coefficients, therefore, it is necessary to know the size of the area draining to the site. The GIS system allows automatic processing of the area delineation. To accomplish this, elevation data were converted into the Digital Elevation Model (DEM). Then the DEM file was converted into the raster grid containing information about the flow direction of water along the surface of the land. When the location of a sampling site is entered into the GIS system, the software automatically delineates the boundary of the area draining into that location.

The GIS data which are used for the Reckhow model currently exist in a vector format which means that they are represented either by polygons, lines or points within ARCINFO vector format. ARCINFO has a database module called INFO which provides the linkage between spatial objects and the database containing information about them.

An interface was developed to link GIS datasets with equations that describe phosphorus loads. It allows a user to display, calculate and modify parameters entered into the model to display different scenarios of the future management. The interface was designed on the basis of "question-answer" communication. It guides a user through all necessary steps.

Another GIS application was created to calculate reservoir volumes which are necessary for reservoir modeling. Within the watershed area there are 19 reservoirs providing drinking water for New York City. Bathymetry data were used for the analysis of reservoir volumes and modeling. Contour maps were found and digitized for 13 reservoirs. This digital database was available for interpolation and digital elevation models (DEM) were created. Using ARC/INFO GIS software and IBM Data Explorer visualization tools, several customized applications were designed to provide information about volumetric changes in the reservoirs associated with changes in surface elevation.

Environmental Rules and Regulations

Environmental Impact Statements (EIS) which are part of the implementation of water quality management, are fully supported by GIS. Different landuse and ownership data with natural features such as streams, soils and lakes were merged to produce a set of maps showing potential scenarios affected by new watershed rules and regulations. Moreover, GIS provided a basis for simulation of these scenarios that resulted in certain buffer types and definitions of the landuse categories. In this particular project the GIS allowed for the modeling and simulation of missing data, such as property boundaries, that provided the necessary accuracy and capability to perform the analysis.

Landuse areas are essential input for a number of environmental models. At the time that the EIS was conducted, there were no recent remote sensing landuse data available, so real estate property data (available as point files) were used instead. In New York State these data are available through the New York State Division of Equalization and Assessment (E&A). Since the E&A data provides only parcel centroids and not actual parcel boundaries, it was necessary to create simulations of parcel areas in order to obtain a spatial representation which would be useable for the various spatial analyses.

The simulation of parcel boundaries was accomplished through a method of interpolation called Thiessen or Voronoy polygons, (or proximal regions). This method is used when data have been collected at points, such as parcel centroids, and the analyst wishes to use area-based analytical techniques. The method consists of generating lines that join nearest neighbor points, then bisecting those lines with perpendicular mediators, and assembling the polygon edges using those lines. The whole procedure was programmed within ARC/INFO macro language code. Once the polygons were created, contiguous land uses were grouped together in clusters using the landuse code, extracted from the real estate attribute tables associated with the point files.

A variable buffer is a spatial model that shows the limits around waterbodies and any other surface hydrological features within which no subsurface sewage treatment system may be built.The variables that change the shape of the buffer are soil types, soil hydraulic conductivity, slope or gradient of the terrain and fixed distances around streams and waterbodies. The GIS was programmed with an algorithm that created a variable buffer. This allowed comparison of experimental scenarios that included different combinations of soil and slope conditions.

Under the Proposed Watershed Regulations minimum buffer distances are set such that no part of any seepage unit or absorption field for a new subsurface sewage treatment system shall be located within 100 feet of a watercourse (stream) or wetland, or 300 feet of a reservoir or lake. By application of the variable buffer model, these limiting distances were found to vary from 100 to 1800 feet according to site specific soil and slope characteristics.

In order to analyse the impacts of the Draft Watershed Regulations on development, the amount of existing vacant developable land in the watershed was determined using GIS. Projected growth for the period 1990-2010 was allocated into the developable vacant land, in order to evaluate the impacts the Draft Regulations would have on future growth. The developable land was defined as land that would be left open for development after the exclusion of all lands that have the following conditions: i) NYSDEC designated wetlands, ii) slopes over 25%, iii) public land, iv) shallow soils, v) land within the impervious surface limiting distance (100 ft. from watercourses and wetlands and 300 ft. from reservoirs, reservoir stems and controlled lakes, vi) parcels that fell completely within or had less than 1/4 acre outside the variable buffer for subsurface sewage discharge treatment systems, vii) clusters of less than one-half acre in places that are not sewered because of existing standards concerning minimum lot sizes for septic systems.

The GIS served as a framework to overlay the conditions mentioned above to produce maps showing developable land polygons. The analysis was performed to establish a baseline for the year 2010 and considering two ten years periods, 1990 to 2000 and 2000 to 2010, to determine potential displacement of new development due to the limiting distances under the Proposed Watershed Regulations. Maps were produced for the whole watershed area on mylars that could be used by planners in conjunction with USGS quads.

Conclusions

GIS implementation in any organization requires three main components: i) GIS hardware and software; ii) The need for spatial data analysis and visualisation and iii) trained personnel.

The most important component in GIS implementation is trained personnel that can solve hardware and software problems and understand the basics of spatial analysis. The personnel should have geographical background and understanding of general GIS capabilities regardless of the software type that is being used.

Variety of GIS applications are succesfully developed by discussion and the working plans between GIS specialists and project managers. The plans should have definite deadlines that consider the software capabilities and GIS specialist's knowledge. Sometimes a preliminary demonstration of GIS capabilities can highlight corrections to the plan and even change the scope of the project.

GIS activities are not limited only to map production; software capabilities allow for many different complicated tasks such as modeling and visualization of natural and anthropogenically improved phenomena.

Monitoring for Cryptosporidium spp. and Giardia spp. and Human Enteric Viruses in the Watersheds of the New York City Water Supply System

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Introduction

The New York City Department of Environmental Protection's Pathogen Program routinely monitors over fifty sites within the watersheds of the New York City water supply system for the presence and density of Giardia spp. cysts, Cryptosporidium spp. oocysts, and enteric viruses. These sites are located at various influents and effluents of the reservoirs, at discharge points of sub-watersheds with different land uses (urban, agricultural, undisturbed), at sewage treatment plants and at areas believed to be affected by wildlife and wetlands (Figure 1). Most sites are monitored on a monthly basis. Kensico Reservoir, the major source water reservoir, is monitored weekly. An attempt is made to monitor at least one storm event per month. The overall objective of this monitoring is to identify the origins, occurrence, density, transport, fate, distribution and control of pathogens within the New York City water supply system.

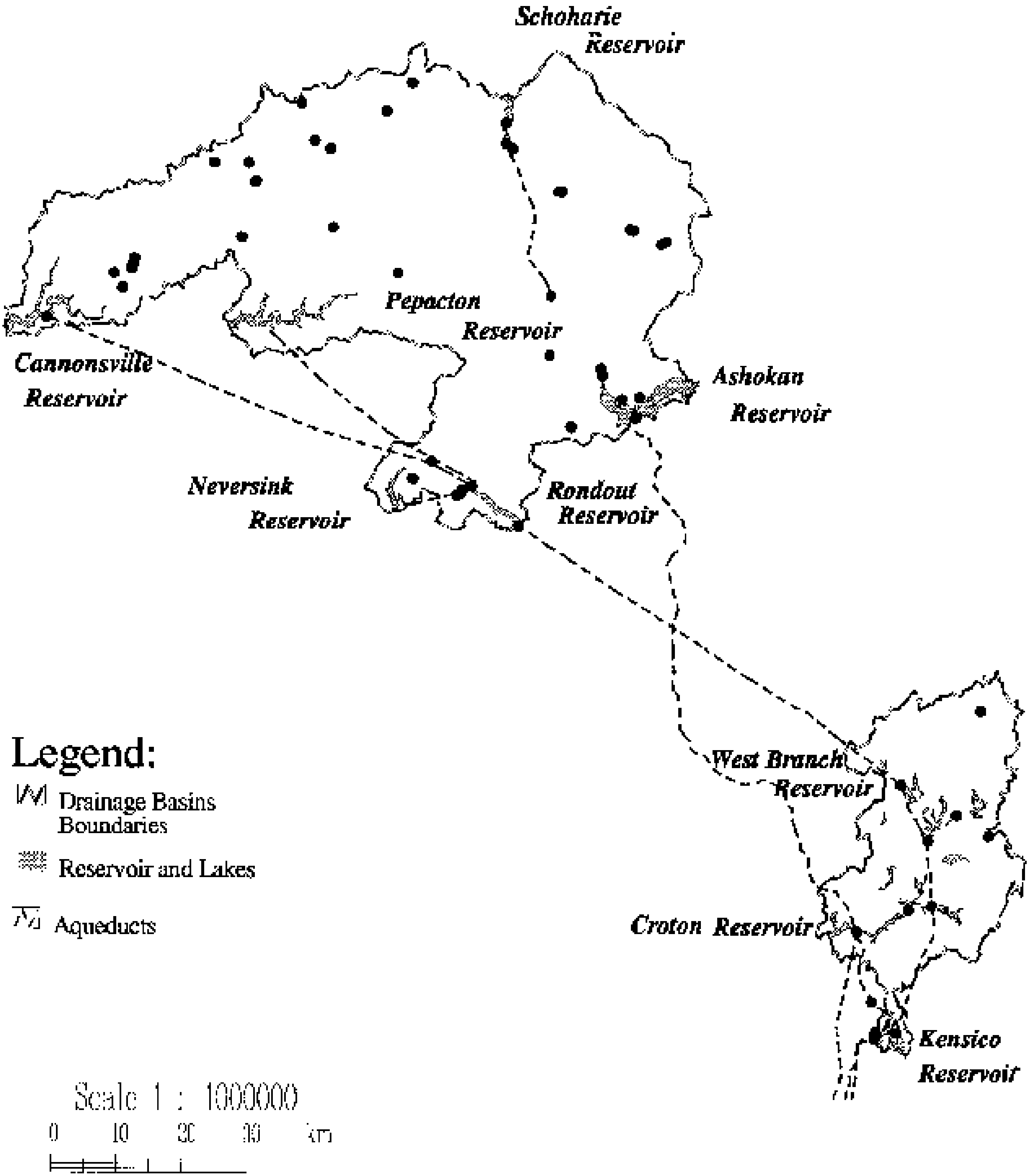

Figure 1. Sampling sites for *Giardia* spp. cysts and *Cryptosporidium* spp. oocysts in New York City watersheds.

Method of Water Quality Analysis

The procedure for the collection and analysis of samples for Giardia spp. cysts and Cryptosporidium spp. oocysts, follows standard method P229 (ASTM 1992) with modifications to ensure a detection limit of less than one cyst per one hundred Liters. This method requires a large sample volume (100-300 gallons) to be filtered at a slow rate (1- gpm) through a yarn-wound, polypropylene filter with a nominal porosity of 1.m. The filters are then washed which elutes the trapped material from the filter fibers. Giardia cysts and Cryptosporidium oocysts are separated from other particles by a series of floatation and centrifugal concentration steps. The sample concentrate is dried on a microscope slide and then stained with fluorescent antibody reagents and examined for the presence of Giardia cysts or Cryptosporidium oocysts under an epifluorescence microscope. Identification of presumptive Giardia cysts or Cryptosporidium oocysts is based on characteristic fluorescence, shape and size. Presumptive cysts and oocysts are further examined for internal structures by differential interference contrast (DIC) microscopy. Presumptive Giardia cysts are considered confirmed if two or more internal morphological characteristics (i.e., nuclei, median body and axoneme) are identified. Presumptive Cryptosporidium oocysts are considered confirmed if one to four sporozoites are observed. DIC examination also allows false positives (or presumed) to be eliminated, if structures not characteristic of Giardia cysts or Cryptosporidium oocysts are observed. An example of this includes observations of choroplasts in a presumed cyst.

Water quality monitoring for human enteric viruses follows standard method 9510 (ASTM 1992). This method also requires a large sample volume (100-200 gallons) to be filtered at a slow rate (1--2 gpm) through a 0.1a.egative virus absorbent filter. Absorbed viruses are eluted from the filter, concentrated using a protein precipitate procedure and than assayed for human enteroviruses using the Buffalo Green Monkey Kidney Cells (BGM) culture test.

Results and Discussion

Virus Sampling

Collection and analyses of water quality samples for human enteric viruses has occurred over the past two years. These samples are collected primarily at the source water reservoirs and at alternating sites throughout the watershed. The results of this sampling indicate that viruses are rarely detected in the watershed. Of the 451 samples collected and analyzed , over 95% did not detect viruses. There was no identifiable pattern based on location or season for these positive detections. Analysis of site or seasonal variability is difficult with such low numbers of positive samples.

Overall Results for Giardia spp. cysts and Cryptosporidium spp. oocysts Sampling

Between June 1992 and December 1995, a total of 1569 samples for Giardia spp. cysts and Cryptosporidium spp. oocysts have been collected and analyzed. Table 1 provides a statistical summary of samples collected throughout the watershed, at the effluents of Kensico Reservoir (the source water reservoir for the New York City water supply), and at the effluent of several wastewater treatment plants.

Table 1. Statistical summary of data collected within the watershed fo the New York City water supply between June 1992 and December 1995. Concentration values are repoted as *Giardia* spp. cysts or

***Cryptosporidium* spp. oocysts per 100 Liters. Total values represent combined presumed and confirmed values.**

SITES	Pathogen	Number of Samples	Percent Detection (%)	Less than values=0		Less than values=detection limit		
				Mean	Max	Mean	Geo.Mean	Max.
WATERSHED-WIDE	**Total Giardia**	**1363**	**27.71**	**1.18**	**109.90**	**2.26**	**1.00**	**149.00**
	Confirmed Giardia	**1363**	**3.59**	**0.07**	**18.30**	**1.51**	**0.79**	**149.00**
	Total Crypto.	**1363**	**21.85**	**0.83**	**121.00**	**2.05**	**0.93**	**149.00**
	Confirmed Crypto.	**1363**	**3.81**	**0.10**	**29.25**	**1.53**	**0.80**	**149.00**
KENSICO RESERVOIR EFFLUENTS	**Total Giardia**	**323**	**24.31**	**0.32**	**9.25**	**1.05**	**0.70**	**9.25**
	Confirmed Giardia	**323**	**2.77**	**0.01**	**0.76**	**0.86**	**5.62**	**0.61**
	Total Crypto.	**323**	**27.38**	**0.50**	**17.30**	**1.22**	**0.77**	**17.30**
	Confirmed Crypto.	**323**	**6.15**	**0.06**	**3.37**	**0.91**	**0.63**	**6.15**
WASTEWATER TREATMENT PLANTS	**Total Giardia**	**206**	**45.71**	**307.58**	**1614.00**	**319.00**	**12.53**	**1641.00**
	Confirmed Giardia	**206**	**17.14**	**39.15**	**3600.0**	**60.95**	**6.72**	**3600.00**
	Total Crypto.	**206**	**20.00**	**6.37**	**184.6**	**29.04**	**5.92**	**512.00**
	Confirmed Crypto.	**206**	**5.14**	**1.01**	**61.6**	**24.83**	**5.25**	**512.00**

An evaluation of watershed samples (all samples except those collected at wastewater treatment plants) indicates that Giardia spp. cysts and Cryptosporidium spp. oocysts are infrequently detected in the watershed. Cryptosporidium spp. oocysts are detected less frequently (found in about 20% of the samples) than Giardia spp.

cysts which are found in about 30% of the samples. Confirmed detections of both pathogenic protozoans are found even less frequently (less than 5% of the samples).

Sampling at Different Land Uses

Analysis of the data has also begun to indicate some discernible differences between sample sites. Cryptosporidium spp. oocysts and Giardia spp. cysts are detected most often in the discharge of wastewater treatment plants, followed by urban watersheds; agricultural watersheds; and then least detected in undisturbed watersheds. This finding is further supported with data from two paired watersheds with higher detections of these pathogenic protozoans at the exclusively agricultural watershed then its nearby undisturbed watershed.

Another discernible difference between sites that has been identified with sites that contain varying acreage of wetland areas. Greater detection of Giardia spp. cysts and Cryptosporidium spp. oocysts was observed at stream segments that contain smaller wetland areas in comparison to stream segments with larger wetland areas.

Sampling at Reservoirs

Water released from reservoirs generally have lower detections of Cryptosporidium spp. oocysts and Giardia spp. cysts than the water entering the reservoir. This is best exemplified at Kensico Reservoir were the largest number of reservoir influent and effluent samples have been collected. On average, Giardia spp. cysts were detected less at the effluents of Kensico Reservoir than at the influents. Cryptosporidum spp. oocysts were detected slightly less at the effluents when compared to the influents. A more pronounced reduction in detection of Cryptosporidum spp. oocysts was observed at the effluents when considering only the percentage of detection of confirmed oocysts.

Overall, the water quality of Kensico Reservoir is quite high relative to the source water quality reported for other water supplies (Archer 1995; LeChevallier et al., 1991; LeChevallier 1995; Ongerth 1989; Rose et al., 1991). The arithmetic mean of total Giardia spp. cysts and Cryptosporidium spp. oocysts leaving Kensico Reservoir is less than 0.6 cysts per 100 Liters

Storm Sampling

The concentration of cysts appear to be much greater during storm events than at base flow conditions. The results of storm sampling at an urbanized stream indicates that the concentration of pathogens can be approximately two to ten times higher during storms than the average levels sampled during base flow. However, the magnitude of these increased concentrations may be exaggerated due to the lower volumes of water that were filtered and the smaller portion of sample that can be examined in the laboratory. Less water is generally filtered during the storm events because stormwater carries high levels of turbidity and suspended solids which causes the collection filters to clog. Similarly, the additional solids in the sample produces a larger sample pellet to be analyzed Both these factors can significantly alter the result of the calculation used to determine the concentration of a sample.

Conclusions

The occurrence of Giardia spp. cysts and Cryptosporidium spp. oocysts is infrequent within the New York City water supply watershed. Some patterns between sampling sites are beginning to be identified and provide insight on the occurrence, transport and fate of these pathogens. However, a large number of samples with positive detections is required before such patterns can be identified.

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The Kensico Watershed Study: 1993-1995

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Introduction

The water supply of the City of New York is one of the largest systems in the world, serving nine million people with 1.4 to 1.8 billion gallons of water each day. The water is collected from an extensive system of 19 reservoirs located in the Catskill Mountains and lower Hudson Valley. Normally, eighty to ninety percent of the water supply is diverted by two aqueducts into the Kensico Reservoir where it resides for approximately two to three weeks before being redirected into the City's distribution system.

The Kensico Reservoir, located in southern Westchester County, New York, plays an integral role in the water supply system. The reservoir has an available storage capacity of 30 billion gallons, allowing for storage of a large quantity of water in close proximity to the City's distribution system. Without Kensico Reservoir the operators of the system would have a difficult time balancing large flows of water from reservoirs located over 100 miles away from the distribution system. Kensico Reservoir also gives the operators of the system the ability to mix water from two large sub-systems, the Catskill and Delaware.

This has proven to be useful for ameliorating occasional water quality problems such as high turbidity originating from only one of the systems. Finally, the reservoir serves to add additional residence time, further enhancing water quality by increasing the settling of particulate matter and the die-off of pathogens.

Water quality monitoring of Kensico Reservoir has revealed very few problems. However, with the advent of the Surface Water Treatment Rule (SWTR) of the Safe Drinking Water Act in 1991 it became apparent that fecal coliform levels in the reservoir were too high at times. Scientists at the New York City Department of Environmental Protection (DEP), the agency responsible for maintaining the City's water supply, observed high fecal coliform concentrations in the reservoir during late autumn and early winter. Fecal coliform concentrations are used by the SWTR as a surrogate measure for the levels of pathogens in a water supply. Turbidity levels are also used by the SWTR as an important indicator of water quality, and for this reason both fecal coliform and turbidity became the focus of many investigations concerning Kensico Reservoir.

New York City's water supply system is currently unfiltered and in the early 1990's the DEP applied to the Environmental Protection Agency for a filtration avoidance waiver for the Catskill and Delaware systems. In anticipation of a filtration avoidance determination, in December of 1993 DEP contracted with Roy F. Weston, Inc. (Weston) to help investigate some of the water quality questions concerning Kensico Reservoir. The results of the joint investigation are summarized in the following paragraphs.

Investigations

Of primary concern to Kensico researchers was isolating the cause of seasonal elevations of fecal coliform in the reservoir. The high numbers of migrating Canada Geese and gulls in autumn and early winter that coincided with elevated fecal coliform concentrations led investigators to believe that birds might be the cause of bacterial problems. Other possible sources considered were: 1. bacteria entering the reservoir from upstate reservoirs via the aqueducts, 2. stormwater flows from the local watershed, which is 13.2 square miles in area and contains eight perennial and numerous intermittent streams, and 3. bacteria entering the reservoir from groundwater.

In 1992, DEP initiated a long-term bird censusing program at Kensico Reservoir. This program indicated immediately that the numbers of geese and gulls roosting on the reservoir, which could be as high as several thousand per day, were unacceptable from a water quality standpoint. In December of 1993, a bird harassment program was started with the goal of moving birds off of the reservoir, thereby reducing the loading of bird fecal matter to the water column. The bird harassment program continued on a seasonal basis in 1994 and 1995, resulting in a yearly reduction in geese and gull counts of approximately 90% compared to pre-harassment counts. This reduction in bird numbers coincided with a dramatic improvement in Kensico Reservoir fecal coliform concentrations. In the autumn of 1994 and early winter of 1995 Kensico water never exceeded the SWTR standard of 20 CFU/100mL, as measured in the aqueducts leaving the reservoir. This improvement contrasted sharply with previous years before the bird harassment program. In 1991 through 1993 fecal coliform concentrations exceeded the limit so often in late autumn that Kensico Reservoir was periodically by-passed by operators, meaning that water was sent directly from the Catskills to the distribution system.

The improvement in water quality gave strong circumstantial evidence indicating birds as a source of fecal coliforms to the reservoir. This was supported by several other pieces of information. In addition to the limnological and hydrological monitoring programs that DEP operates, a microbiological group was formed to focus specifically on determining the sources of fecal coliforms. Using the various types of phage present in fecal coliform bacteria, the microbiology group was able to implicate birds as the origin of many of the fecal coliforms collected from the reservoir. The microbiologists also used serological analysis and a comparison of fatty acids to help determine the origin of fecal coliforms. DEP also developed a mathematical model using multiple regression to indicate that bird counts on the reservoir had the most predictive power for determining fecal coliform concentrations in water leaving the reservoir. Finally, consultants from Weston organized the information that DEP had collected regarding fecal coliform loading to the reservoir so that it could be used to show that birds contribute the majority of the fecal coliform load.

Concurrent with the investigation of birds as a source of fecal coliform were studies into the other potential sources of fecal coliforms. These studies showed that stormwater flows were the second most problematic source of fecal coliforms. Kensico tributaries were monitored both on a routine basis and during storm events for a variety of parameters including fecal coliform concentrations and turbidity. An analysis of the load of fecal coliform entering the reservoir from stormwater showed that high percentages of the total reservoir fecal coliform load could be delivered by stormwater to the reservoir in short periods of time. In addition, some streams enter the reservoir in close proximity to the effluents, effectively by-passing the reservoir's capacity to eliminate pathogens by settling or die-off. Stormwater studies also included the use of the SWMM model by Weston to simulate tributary flows and loadings. Finally, DEP is continuing investigations into the sources of stormwater fecal coliform. Among other projects, this includes television inspection of the sewer pipes in the watershed.

Other sources of fecal coliform have not been shown to be a substantial factor in Kensico fecal coliform levels. Although the load of fecal coliform entering the reservoir from the aqueducts is a large percentage of the total load, the majority of these fecal coliforms are thought to die or settle before reaching the effluents. This is supported by the lack of an apparent statistical relationship between fecal coliform loads entering the reservoir and loads leaving the reservoir. Through a sub-contracting firm, Weston also examined the hydrodynamics of the reservoir with two dye studies, and the results show that the reservoir probably has enough residence time for many of the fecal coliforms to die or settle. A hydrodynamic model was also developed that will be used as a tool for examining the fate of fecal coliforms originating from the aqueducts.

Groundwater has not been shown to be a substantial source of fecal coliforms. Eighteen test wells were drilled around Kensico Reservoir in 1994. A monitoring program has not found high concentrations of fecal coliform in the wells, with the exception of two wells that are known to be in the vicinity of sources of fecal coliform.

Remediation

In addition to examining the sources of fecal coliforms to Kensico Reservoir, researchers have been examining various methods of remediating water quality problems. Out of a variety of techniques for improving water quality a plan was developed that includes four elements. The most important element of the plan is the bird harassment program that was mentioned earlier. This involves noisemakers and patrol boats and has already demonstrated its effectiveness.

The second most important element of the plan is the construction of stormwater Best Management Practices (BMPs) and spill control devices. By reducing erosion and increasing the capacity for pollutants to settle out of stormwaters these devices should reduce the load of pollutants that enter the reservoir. Beginning in 1997 approximately 77 BMPs will be constructed in the Kensico watershed, along with twelve spill control devices that will be placed along the eastern shore of the reservoir. Proposed BMPs include: extended detention basins, outlet stilling basins, check dams, current deflectors, and various streambank stabilization plans.

Another element of the remediation plan is the placement of a curtain wall in one of the reservoir's two effluent coves. The purpose of the curtain wall is to deflect stormwater away from the effluent allowing for more mixing and settling. The curtain wall was installed in the reservoir in 1995, and its effectiveness has not yet been determined.

Finally, the last element in the program is periodic dredging of the sediments immediately in front of the effluent buildings. This practice will be undertaken primarily as a maintenance measure, but it is hoped that there may be the secondary benefit of an improvement in water quality.

Conclusion

Investigations into the water quality issues related to Kensico Reservoir have led to dramatic improvements in the water supply of New York City. It is apparent that birds can be a substantial cause of fecal coliform problems in drinking water supplies, and similarly, their control can help eliminate those problems. Although there are many outstanding questions regarding the sources of pollutants to the reservoir, much of the pollution control work has been completed and a plan has been developed that will further improve the quality of Kensico water.

Watershed Planning: Evaluating Investments in Nonmonetary Resources

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Web Note: *Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

Introduction

Our Nation's watersheds provide us with a wide variety of goods and services. Historically, watershed management by the U.S. Army Corps of Engineers (COE) and the other federal water agencies tended to focus on flood damage reduction, navigation, water supply, recreation, hydropower, and other economic development outputs. In this context, benefit-cost analysis has evolved as the established decision tool for project evaluation in federal water programs. Benefit-cost analysis is well suited to planning for traditional purposes, such as flood control, where both costs and benefits of management plans can be accounted for in a common metric the dollar.

While many of the economic values of our watersheds have been successfully exploited, we have come to realize that there are other watershed values which, although they cannot be measured in dollars, are just as important to our Nation's health and welfare. These range from values of localized fish and wildlife habitats to entire ecosystems. As a result, new legislative authorities provide the COE with opportunities to pursue environmentally-oriented projects, which are afforded equal priority to traditional flood control and navigation projects in the COE budget. This paper presents a methodology for the economic evaluation of alternative plans aimed at providing nonmonetary benefits, such as ecosystem restoration plans.

Watershed Planning and Management: Costs and Benefits

Figure 1 provides a framework for discussing the different types of costs and benefits resulting from watershed management plans. Tomorrow's balanced, or "sustainable," solutions will be found in the fresh territory represented by Quadrant I. Here, multi-objective watershed management activities provide not only traditional economic goods and services, but also beneficial effects to the ecosystem and other values. Here we find solutions which, while not without costs, will produce net benefits both monetary and nonmonetary.

Historically, watershed planning was focused on economic development; usually at the expense (albeit unintended) of environmental and other values; such options fall in Quadrant II. Our presentation in this paper will address a framework for evaluating solutions intended to produce ecosystem and other nonmonetary benefits that have (again, some unintended) net economic costs; such solutions fall in Quadrant IV.

When pursuing less traditional nonmonetary outputs, such as environmental restoration benefits, classic benefit-cost analysis becomes less useful. While the costs of watershed improvements and management plans can still be measured in dollars, there is no universally acceptable unit of measurement for many environmental benefits-dollars or otherwise. Still, decisions must be made regarding whether management actions aimed at restoring or preserving environmental (or other nonmonetary) resources should be implemented; and if so, at what scale. Although it is currently not possible to conduct traditional benefit-cost analysis where nonmonetary watershed benefits will result, other analytical tools, such as cost effectiveness and incremental cost analyses, are available to inform such decision making.

Cost Effectiveness and Incremental Cost Analyses

In their National Strategy for the Restoration of Aquatic Ecosystems, the National Research Council (NRC) states that, in lieu of benefit-cost analysis, the evaluation and ranking of restoration alternatives should be based upon a framework of incremental cost analysis "Continually questioning the value of restoration by asking whether an action is 'worth' its cost is the most practical way to decide how much restoration is enough." (NRC 1992) As an example, the council cites the COE's approach where "a justifiable level [of output] is chosen in recognition of the incremental costs of increasing [output] levels and as part of a negotiation process with affected interests and other federal agencies." (NRC 1992)

As outlined in this paper, cost effectiveness analysis is performed to identify the least cost solution for each possible level of nonmonetary output under consideration. Subsequent incremental cost analysis reveals the increases in cost that accompany increases in the level of output, asking the question: "As we increase the scale of this project, is each subsequent level of additional output worth its additional cost?"

Data Requirements: Solutions, Costs and Outputs

Cost effectiveness and incremental cost analyses may be used for any scale of planning problem, ranging from local, site-specific problems to more extensive watershed and ecosystem scales. Regardless of the problem-solving scale, three types of data must be obtained before conducting the analyses: a list of solutions, and for each solution, estimates of its ecosystem or other nonmonetary effects (outputs) and of its economic effects (costs).

The term "solutions" is used here to generally refer to techniques for accomplishing planning objectives. For example, if faced with a planning objective to "Increase waterfowl habitat in the Blue River Watershed," a solution might be to "Construct and install 50 nesting boxes in the Blue River riparian zone." Solutions may be individual management measures (for example, clear a channel, plant vegetation, construct levee, or install nesting boxes, for example), plans (various combinations of management measures), or programs (various combinations of plans, perhaps at the watershed level).

Solutions' cost estimates should include both financial implementation costs and economic opportunity costs. Implementation costs refer to direct financial outlays; for example, costs for design, real estate acquisition, construction, operation and maintenance, and monitoring. The opportunity costs of a solution are any current benefits available with the existing state of the watershed that would be foregone if the solution is implemented. For example, restoration of a river ecosystem may require that some navigation benefits derived from an existing river channel be given up in order to achieve the desired restoration. It is important that the opportunity costs of foregone benefits be accounted for and brought to the table to inform the decision-making process.

The level to which a solution accomplishes a planning objective is measured by the solution's output estimate. Historically, environmental outputs have been expressed as changes in populations (waterfowl and fish counts, for example) and in physical dimensions (acres of wetlands, for example). In recent years, output estimates have been derived through a variety of environmental models such as the U.S. Fish and Wildlife Services' Habitat Evaluation Procedures (HEP), which summarize habitat quantity and quality for specific species in units called "habitat units." Models for ecological communities and ecosystems are in the early stages of development and application, and may be more useful at the watershed scale.

Cost Effectiveness Analysis

In cost effectiveness analysis, solutions that are not rational (from a production perspective) are identified and screened out from inclusion in subsequent incremental cost analysis. There are two rules for cost effectiveness screening. These rules state that solutions should be identified as inefficient in production, and thus not cost effective, if: 1) the same level of output could be produced by another solution at less cost; or 2) a greater level of output could be produced by another solution at the same or less cost.

Table 1. Solution, Costs and Outputs.

SOLUTION	UNITS OF OUTPUT	TOTAL COST ($)
No Action	0	0
A	80	2,000
B	100	2,600
C	100	3,600
D	110	4,500
E	120	3,600
F	140	7,000

For example, look at the range of solutions in Table 1. Applying Rule 1, Solution C is identified as inefficient in production-why spend $3,600 for 100 units of output when 100 units can be obtained for $2,600 with Solution B; a savings of $1,000. In this example, Solution C could also be screened out by the application of Rule 2-why settle for 100 units of output with Solution C, when 20 additional units can be provided by Solution E at the same cost. Also by applying Rule 2, Solution D is screened out-why spend $4,500 for 110 units when 10 more units could be produced by E for $900 less cost.

Figure 2 shows the "cost effectiveness frontier" for the solutions listed in Table 1. This graph, which plots the solutions' total cost (vertical axis) against their output levels (horizontal axis), graphically depicts the two screening rules. The cost effective solutions delineate the cost effectiveness frontier. Any solutions lying inside the frontier (above and to the left), such as C and D, are not cost effective and should not be included in subsequent incremental cost analysis.

Incremental Cost Analysis

Incremental cost analysis is intended to provide additional information to support a decision about the desired level of investment. The analysis is an investigation of how the costs of extra units of output increase as the output level increases. While total cost and total output information for each solution are needed for cost effectiveness analysis, incremental cost analysis requires data showing the difference in cost (incremental cost) and the difference in output (incremental output) between each solution and the next-larger solution.

Continuing with the previous example, the incremental cost and incremental output associated with each solution are shown in Table 2. Solution A would provide 80 units of output at a cost of $2,000, or $25 per unit. Solution B would provide an additional 20 units of output (100-80) at an additional cost of $600 ($2,600-$2,000). The incremental cost per unit (incremental cost divided by incremental output) for the additional 20 units B provides over A is, therefore, $30. Similar computations can be made for solutions E and F. Solutions C and D have been deleted from the analysis because they were previously identified as inefficient in production.

SOLUTION LEVEL OF OUTPUT COST ($)

	Total Output	Incremental Output	Total Cost	Incremental Cost	Incremental Cost Incremental Output
No Action	**0**	**-**	**0**	**-**	**-**
A	**80**	**80**	**2,000**	**2,000**	**25**
B	**100**	**20**	**2,600**	**600**	**30**
E	**120**	**20**	**3,600**	**1,000**	**50**
F	**140**	**20**	**7,000**	**3,400**	**170**

Table 2. Incremental Cost and Incremental Output.

The incremental cost and output data in Table 2 are plotted in Figure 3. The incremental cost per unit is measured on the vertical axis, while both total output and incremental output can be measured on the horizontal axis. The distance from the origin to the end of each bar indicates total output provided by the corresponding solution. The width of the bar associated with each solution identifies the incremental amount of output that would be provided over the previous, smaller-scaled solution; for example, Solution E provides 20 more units of output than Solution B . The height of the bar illustrates the cost per unit of that additional output; for example, those 20 additional units obtainable through Solution E cost $50 each.

Decision Making-"Is it Worth It?"

Figure 3 presents cost and output information for the range of cost effective solutions under consideration in a format that facilitates the investment decision of which (if any) solution should be implemented. This decision process begins with the decision of whether it is "worth it" to implement Solution A.

Both Table 2 and Figure 3 show Solution A provides 80 units of output at a cost of $25 each. If it is decided that these units of output are worth $25 each, then the question becomes should the level of output be increased? To answer this question, look at Solution B, which provides 20 more units than Solution A. These 20 additional units cost $30 each-"are they worth it?" If "yes", then look to the next larger solution, E, providing 20 more units than B at $50 each-again asking "are they worth it?" If it is decided that E's additional output is worth its additional cost, then look to F, which provides 20 more units than E at a cost of $170 each.

Cost effectiveness and incremental cost analyses will not result in the identification of an "optimal" solution as is the case with benefit-cost analysis. However, they do provide information that decision makers may use to facilitate and support the selection of a single solution. Selection may also be guided by decision guidelines such as output "targets" (legislative requirements or regulatory standards, for example), minimum and maximum output thresholds, maximum cost thresholds, sharp breakpoints in the cost effectiveness or incremental cost curves, and levels of uncertainty associated with the data.

The analyses are also not intended to eliminate potential solutions from consideration, but rather to present the available information on costs and outputs in a format to facilitate plan selection and communicate the decision process. A solution identified as "inefficient-in-production" in cost effectiveness analysis may still be desirable; the analysis is intended to make the other options and the associated tradeoffs explicit. Reasons for "selecting off the cost effectiveness curve" might include considerations that were not captured in the output model being used, or uncertainty present in cost and output estimates. Where such issues exist, it is important that they be explicitly introduced to the decision process. After all, the purpose of conducting cost effectiveness and incremental cost analyses is to provide more, and hopefully better, information to support decisions about investments in environmental (or other nonmonetary) resources.

References and Resources (resources indicated by an asterisk are available at the address below)

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* Copies of these reports can be obtained from:

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Resource Significance in Environmental Project Planning

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Introduction

Resource significance, significant resources, significance of the resource, environmental significance, these are all terms that are used when describing natural resources which have been judged by someone to be of some special value to the environment and also to society. They include resources such as plant or animal species or groups of species, wetlands, rivers, lakes, estuaries and marine areas. Some may argue that all wetlands are significant and this would be difficult to dispute given the vast losses of wetlands in recent decades. The same may be said for rivers, lakes, species, estuaries and marine areas. Again, who can dispute this claim? While most of us agree that these natural resources are significant, we also agree that some of them are more significant than others. To illustrate this point, consider the bald eagle and its place in your value system compared to the crow. Most people asked to determine which of these species is most significant would select the eagle. Why? The bald eagle is our national symbol. It has been admired throughout the ages as a symbol of strength and courage. Furthermore, the bald eagle was considered an endangered species (ES) for a long time. At the time of placement on the ES list, their numbers were declining and there was considerable doubt as to whether they would survive as a species. Crows, on the other hand, recognizing that they do contribute to ecological importance, are more abundant. They inhabit areas close to human populations and often are considered a nuisance. The bald eagle, in our society, is a more significant resource than the crow.

The argument about the eagle and the crow is easy to make. Most of us could make this argument, and if necessary, could convince a decision maker that the eagle deserves more of our resources (money, effort) than the crow. Unfortunately, comparisons of species and certainly comparisons of other natural resources are not always so clear. There are characteristics about all natural resources that need to be examined, scrutinized and evaluated within the context of their natural setting. What are the characteristics that make each resource significant? How can we learn more about specific resources and make value judgements about their significance? Furthermore, how can we convey this information to decision makers to more effectively use available resources or to enhance our chances of securing additional resources or funding required to protect, restore or enhance the significant natural resources in question?

The Corps of Engineers Evaluation of Environmental Investments Research Program (EEIRP) contains several different work units designed to address difficult questions regarding environmental projects. One of the work units, Determining and Describing Environmental Significance, attempts to provide a framework to systematically address the issue of resource significance. A discussion of that effort is presented below.

Problem and Objective

Environmental restoration planning in terms of mission is relatively new to the Corps of Engineers. The Corps has been responsible for maintaining the nation's navigable waterways for more than 100 years. Other long standing Corps missions include flood control and hydroelectric power. The Corps has become expert in planning, designing and building to support these missions over the years. In due time, the Corps will also become proficient in planning, designing and building for environmental purposes. However, for now, there is a steep learning curve.

Environmental considerations in project planning have been required in legislation, including the National Environmental Policy Act (NEPA) since 1969. However, flooded natural wetlands don't command the same attention as flooded towns suffering millions of dollars in damages. Clogged or polluted streams don't get the level of attention (funding) that navigable rivers which carry valuable commodity flows receive. Species depletion, even of endangered species, doesn't rate very high on the demand scale versus hydroelectric power production. Environmental resources: Species; Wetlands, Rivers; Lakes, Estuaries and Marine areas are just starting to receive considerable recognition as valuable resources within the Corps Civil Works programs. There is endless potential for work to improve environmental resources. However, to "fix" all of them would be impossible. There are too many natural resource problem areas and too few dollars to address them. Furthermore, the relatively neat, clean and defendable benefit/cost analyses are not available for justification of environmental projects. So how do we decide which resources and specifically which potential projects to address?

Resource significance is one place to start. The "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies," (P&G) written by the U. S. Water Resources Council, define significance based upon institutional, public and technical recognition. The document states that, "Significant EQ (environmental quality) resources and attributes that are institutionally, publicly, or technically recognized as important to people should be taken into account in decision making." Essentially, the P&G states that significant resources are worth protecting and they should be considered when carrying out other project purposes.

When the P&G were written, the major concern was protecting from further harm, those significant resources that stood to be damaged or destroyed as a result of a project such as a dam or levee construction for flood control purposes. In fact, the meaning of the term significance took on more importance from the context of "significant effect" on resources. The EQ goal often was not part of the original plan but rather an afterthought and then, the effort was directed towards reducing the significant effect of the original action on natural resources. Planners and engineers were obliged to take these effects into account, but they were not obliged to unduly disrupt the original project purpose for environmental concerns. Significant environmental resources were viewed as a threat to the original project purpose.

The tables have turned a full 180 degrees. The concept of resource significance has taken on an entirely new meaning. Ecosystem restoration is now a Corps mission. Rather than being viewed as a negative to another project purpose, protecting and restoring significant resources have become a project purpose. Significant resources that can be demonstrated to be important to people from an institutional, public or technical perspective, may become the projects of the future. At a minimum, such resources can be deemed deserving of further consideration in the environmental planning arena. The objective of the significance work unit is to define ways of determining significance and perhaps, more importantly, stress the importance of effectively communicating the issue of significance to local planning partners, stakeholders and decision makers.

Approach and Products

In order to systematize the process of determining resource significance, it was felt that a methodology or protocol would be a useful document for planners. The initial step was to review and consider what had been or was already being done. Recognizing the need for determining and describing resource significance in ecosystem restoration, a literature review was initiated under the Corps' Planning Methodologies Research Program. This effort produced a "Review and Evaluation of Programs for Determining Significance and Prioritization of Environmental Resources," IWR Report 94-R-7 (September 1994).

When the EEIRP became an official program in late 1994, work was begun within the Significance Work Unit to produce interim guidance or information on the use of significance in environmental planning and evaluation. "Resource Significance: A New Perspective for Environmental Project Planning," IWR Report 95-R-10 was completed in June 1995. This report provided a summary of the previous review and introduced the concept of a protocol for including a significance assessment in environmental project planning. A companion document, "Significance in Environmental Planning: Resource Document," IWR Report 96-R-___ (February 1996), provides information and guidance on resources available to support the use of the significance protocol. The document contains numerous citations of laws and existing programs which may help determine and document significance as well as illustrative examples of how the significance arguments can be structured to enhance the communication of resource significance to project reviewers and decision makers.

The final document of the Significance Work Unit is the "Significance Protocol and Worksheet," an easy-to-use-guide for identifying and describing resource significance in environmental project planning. The primary objectives of the protocol are to assist planners in: establishing the Federal interest in a proposed restoration project and a level of priority for the project at the national, regional, state and local levels; evaluating individual project plans within the context of the ecosystem; communicating information to decision makers to support project justification; and ultimately communicating information to decision makers to assist in allocating resources among different projects.

The protocol provides an iterative procedure for identifying and describing resource significance in environmental plan formulation and evaluation. Four activities are included_scoping, analyzing, evaluating, and communicating_that are referred to as phases of the protocol. Each phase consists of several steps, with a total of 12 steps to complete the four phases of the protocol. One or more iterations of these four phases will guide a planning team through the process of identifying and describing resource significance.

The purpose of each phase in the protocol is summarized below:

1. Scoping Phase. Identify and document the full range of potentially significant environmental resources related to the study area for a proposed restoration project.

2. Analytical Phase. Determine and document specific sources of priority recognition; collect and analyze information to describe the institutional, public, and technical significance of particular environmental resources; and, if appropriate, examine the significance of each resource through analyzing relative importance rankings, levels of significance, and signifiscores.

3. Evaluation Phase. Determine the most significant resources by further prioritizing resource significance, evaluate the significance determinations against Corps policy, planning, and budgetary guidance (e.g., the need to establish a Federal interest) to further prioritize among significant resources.

4. Communication Phase. Develop narrative arguments describing the determinations of significance, which will be included in planning reports.

Applications

Environmental project planning for ecosystem restoration includes addressing the specific problems and needs of any one or group of species, wetlands, rivers, lakes, estuaries and marine areas or various combinations of these. However, the funding available for addressing these problems is extremely limited. Consequently, there must be some methodology or screening process to eliminate certain projects from further consideration while recognizing other projects that warrant further study. An analysis of the significance of resources can help to support project justification at any level as well as help to determine whether there is a Federal interest. Resource significance offers a screening tool for making initial decisions about project worthiness, and, may also serve as a decision making tool to aid in selecting the best or "most significant" projects from among a group of deserving projects that must compete for limited funds.

As an illustrative example, consider that there are numerous plant and animal species in the environment that could and would benefit from the right kind of planned activities. How are we going to select which species or groups of species we want to spend money on? Information about the species must first be compiled.What is the species(es) to be addressed? Is it an endangered species, included in the Federal or state list of endangered species? Is the species' existence threatened or endangered in the current or do nothing environment? Is it seen as an important resource to the region, the state and or to local interests? Why is the species important? Commercial, recreational, existence or other values? Will other important resources be adversely affected if this species continues to decline? Conversely, will other significant resources benefit by actions taken to restore or enhance the resource being addressed? Ultimately, the more significant resources to be affected by a project, the better the chances that the project will receive decision support and funding. As the Corps of Engineers Engineering Circular 1105-2-210 explains, the Corps mission is to focus on Ecosystem Restoration as opposed to individual resource restoration.

Conclusion

Environmental projects are non-traditional projects within the Corps of Engineers. However, ecosystem restoration has been recognized as a mission of the Corps and therefore will require new planning techniques and approaches in order to be effective. Resource significance is just one of many tools now being developed within the Corps to assist in the planning and decision making process. The significance of a resource in the eyes of local, state, regional and national interest can help to determine whether there is a Federal interest in the project and thus, help to justify Corps of Engineers involvement. Resource significance in the context of ecosystem management can assist decision makers to select the best and most significant projects to protect, preserve or enhance the more threatened and/or the more significant resources. With limited funding to support projects of any kind, it will be the projects that show the most potential for improving the widest range of resources, to include contributing to existing nationally recognized resource programs such as the National Wildlife Refuge System or the North American Waterfowl Management Plan.

Future Steps

The major focus of this effort has been to address resource significance within the context of project planning for restoration activities. However, within the Corps of Engineers, there are at least two other potential uses for the resource significance arguments. One of those uses is within the management of

Corps owned property surrounding major projects. Many of these projects have extensive land holdings which are managed for recreational and other purposes. As in the new project arena, funding for land management is becoming more limited and resource managers must become more selective about which resources they want or need to address with their limited funding. An analysis of the projects with a focus on resource significance both within and beyond the boundaries of the immediate project could help project managers decide the most beneficial use of available funding.

Another potential use of resource significance analysis is in the Corps' Regulatory Permit Evaluation Process. Section 404 of the Clean Water Act requires a permit for all potential development impacting on a wetland. The developer is required to avoid damages where possible and to mitigate for those unavoidable damages. Mitigation guidance emphasizes replacement of functions and values where possible or a minimum of one-to-one replacement of area. Use of a resource significance assessment tool could greatly enhance the Corps' ability to better evaluate the functions and values of wetlands and ultimately to require more appropriate mitigation measures that may contribute to other regional and national environmental goals or programs such as the Chesapeake Bay Program.

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Endnote

1. The views expressed in this paper are those of the authors and not of the Department of the Army or the U. S. Army Corps of Engineers.

Linking Environmental Project Outputs and Social Benefits: Bringing Economics, Ecology and Psychology Together

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Web Note: *Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

Introduction

Environmental projects introduce features that can be measured in monetary terms as well as features that cannot, or should not, be monetized. In order to effectively evaluate the benefits and costs of ecosystem outputs, the linkages between changes in ecological resources, which may be measured by various habitat assessment techniques, and ecological outputs and services, which may have socioeconomic value, need to be clearly defined. Once these linkages are understood, there are two approaches to including the ecosystem outputs and services in the decision making process; either a monetary value can be placed on the output, or the output can be presented to decision makers in a nonmonetary fashion for their consideration.

This paper addresses two questions: (1) what are the possible changes in the ecosystem which may result from environmental mitigation or restoration projects, and what outputs and services do these changes provide society? and (2) what are effective approaches to communicate to decision makers the linkages between ecosystem functions and socioeconomic benefits in a manner which allows them to construct values for ecosystem functions?

Linking Ecosystem Outputs to Human Services

The conception of potential projects starts with the identification of a restoration need, which may be provided through a number of alternative management actions (see Figure 1). Often, a proposal not only identifies need but also suggests at least some management alternatives such as building a dike or dam, eliminating existing water control structures, redistributing bottom sediments, or harvesting aquatic plants. Planners are expected to evaluate the need and the various management alternatives to determine which is the most cost effective in providing the need. Each of the alternative proposed actions directly and indirectly generates environmental changes, which can be categorized as: Morphology and Topography, Water and Material Transport, Substrate, Habitat Arrangement, Water Quality, and Biological Quality (Cole et al., 1996).

In order to determine the possible changes in the ecosystem which may result from environmental mitigation or restoration projects, it is necessary to take an ecological systems approach. This approach allows the planning team to not only identify first round direct effects on the ecosystem, but also the indirect, and often unanticipated effects, of management actions. Cole et al. (1996) developed a series of tables_one for each of the above categories of environmental effects_which allow the planner to progress from management control (e.g. water depth), to ecological output and its measure (e.g. clearance to bottom in feet), to the human service (e.g. boating). The tables are designed to bring together the expertise of the economist and biologist on the planning team in the development of a robust set of potential project outputs for plan formulation and evaluation.

The tables facilitate identification of a range of direct ecological effects, and associated human services, which could result from changing ecological inputs. For example, within Morphology and Topography (Table 1), it can be seen that increased water surface area can directly increase the use area for boating and swimming. Additionally, many effects of management actions are indirect, and these effects are traceable by referring the planning team to a different table within the series. In this case, wildlife recreation may be effected by the change in surface area, therefore the planner is directed to the Biological Processes table. As shown in Figure 1, many feedbacks occur in real ecosystems and in the suite of tables, and should be traced accordingly.

The approach offered by Cole et al. (1996) provides the planner a checklist of possible ecological outputs and associated human services which might result directly and indirectly from the management options under consideration. In many cases, however, an effect may not be worth pursuing because there may be no demand for the output or human service, or pursuing it further would require an expansive data collection effort. The following test offers the planning team a filter to refine the list of effects to those worth pursuing for plan formulation and evaluation:

1. Is there a legal requirement to evaluate the output/service? If yes, then do so. If no, go to (2).

2. Is there a demand for added amounts of the output/service? If yes, go to (4). If no, go to (3).

3. Is this output/service important to a stakeholder? If yes go to (4). If no, drop out.

4. Can meaningful differences in the level of output/service be measured across different alternatives or scales of action? If yes, go to (5). If no, drop out.

5. Are the data available to measure this output/services or is there sufficient resources to collect such data. If yes, then evaluate. If no, drop out.

The results of the above described analysis will be a list of "significant" outputs/services which the planning team will want to investigate further and describe, either quantitatively or qualitatively, as part of the project justification. The question now facing the planning team is, how should these outputs/services be described?

Describing the Socioeconomic Value of Ecosystem Outputs and Human Services

Traditional water resource projects are justified for the most part by showing that they have positive net national economic development (NED) benefits. However, environmental restoration, by its very nature, is justified not in NED terms, but rather on the positive environmental impacts which the project produces. These benefits are then weighed against the cost of the project, and the project is considered justified if the environmental improvement is "worth" the cost. This difference in project justification has been institutionalized by the U.S. Army Corps of Engineers (COE) by the issuance of recent guidance. However, the question remains, how does one determine if a project is "worth" its costs.

One alternative is to revert back to the NED approach, and attempt to place monetary values on all environmental project outputs. If this were possible, then costs and benefits could be compared in a common metric, and the net positive NED rule would be applicable. Another alternative is to provide the decision makers with a vast list of project outputs_in terms such as habitat units, species populations, acres restored_and allow the decision makers to weight the costs of the projects against these benefits. In actuality, both of these alternatives are probably unacceptable. The first is plagued by our inability, or unwillingness, to place dollar values on the environment. This is complicated further by equity issues such as the appropriate role of discounting, the possibility of making irreversible decisions, and inter-generational equity. The second is plagued by the immense amount of data which must be considered by the decision maker, and the inability to consider trade-offs between so many different types and levels of outputs and services.

A hybrid approach would be to reduce some outputs to monetary values through standard NED benefit calculations, hence reducing the number of different metrics which must be considered by the decision makers. Consider, as an example, two project alternatives. The first has annualized costs equal to $5 million, and will produce harvestable fish, swimming opportunities, and protect 400 acres of habitat. If the fish can be valued at $3 million per year, and the swimming at $1 million per year, then the project can be represented as 400 acres of habitat at a cost of $1 million per year. The second alternative has annualized costs equal to $7 million, and will produce harvestable fish, swimming opportunities, provide a flyway for a threatened species, and protect 400 acres of habitat. If the fish can be valued at $3 million per year, and the swimming at $2 million per year, then the project can be represented as providing a flyway and 400 acres of habitat at a cost of $2 million per year. As this example illustrates, as more outputs are monetized, the trade-offs which must be considered by the decision makers become more manageable.

However, the choice of which outputs to monetize, and the final decision about which alternative is "better" is still left to the decision makers. Shabman (1995) points out, "(project justification) must be made to convince those who can block or advance a restoration alternative about the merits of the project. This means that the analysis required for justification can only be determined after determining what will be acceptable to the relevant decision makers." This being true, how can the planner be sure that the analysis required for justification will be acceptable to decision makers? This question can be answered by examining the uniqueness of environmental projects, and the decision makers' role within these projects.

In recognition of the important role decision makers play in environmental decisions, Schkade evaluated the psychology (i.e. perceptions, values, priorities, decision criteria) of stakeholders through a series of interviews and focus groups surrounding COE environmental projects. Several observations defined some of the unique differences between the planning philosophies of environmental and traditional COE projects. First, it is clear that restoration ecology is an evolving science, and hence a great deal of uncertainty surrounds restoration projects. Therefore, restoration requires experimentation and ongoing adaptive management. Second, since restoration is a relatively new activity, no single player in the planning process can assume it has a monopoly on technical expertise or experience. Hence, a collaborative planning environment is essential. Lastly, environmental projects are popular, and hence, a cooperative approach to planning is feasible and probably more efficient.

Given these findings, it is clear that the valuation of environmental project outputs requires participation by decision makers throughout the planning process. Unlike in the case of tradition water resource projects, it is not enough to determine project outputs, place values on them, using monetary and other valuation techniques, and then attempt to justify the project to decision makers using these values. First, environmental projects are very often multi-output projects, therefore the mix of outputs chosen may not be acceptable to the decision makers. Second, since environmental outputs are often not traded in the market, the techniques used to place values on the outputs_such as the contingent valuation method_may not be believable to decision makers. Third, each decision maker brings scarce information concerning the new science of environmental restoration to the table. Lastly, active involvement is demanded by decision makers who want to insure that their interests are incorporated into the final project. Therefore, we argue that valuation of environmental outputs requires a new breed of group decision making.

Decisions must be made by stakeholders throughout the planning process regarding not only project features, but also output prioritization procedures.

Conclusion

Environmental projects are complex, multi-output projects, and often these projects have outputs which are the result of indirect, and unintended effects. By taking a systems approach, as incorporated into the tables described above, it is possible to identify the significant ecological outputs and associated human services which will result from a project alternative. Choosing among these project alternatives requires making decisions about output priorities. Unlike traditional water resource projects, environmental projects are measured in many metrics, dollar values being only one of them. Therefore output prioritization cannot be reduced to a single metric based decision rule, such as positive net national economic development. An alternative decision making protocol, which lends itself well to the characteristics of environmental project planning, is to involve decision makers throughout the process. This includes gaining acceptance of valuation techniques which will be used to choose between project alternatives.

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Customizing Corps Planning for Environmental Restoration: An Evaluation Framework

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Web Note: *Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

Introduction

Many federal resource agencies are realigning their activities to accommodate the publics' desire for environmental enhancement, restoration and preservation. This includes traditional water resource development agencies such as the Bureau of Reclamation and Army Corps of Engineers (COE) which are bolstering involvement in environmental restoration projects. Plan formulation for federal projects follow the Water Resources Council's (1983) guidelines (commonly referred to as the Principles and Guidelines or P&G) that were designed to ensure economically sound developments while considering environmental and other impacts. In support of the economic analyses required by the P&G, many analytical tools have been developed to forecast, measure, and evaluate the impacts of water resource projects. However, many of these methodologies are challenged by the nonmonetary/noneconomic parameters brought forth through environmental restoration.

This paper describes the COE response to increasing involvement in ecosystem restoration projects which surfaced the need to customize and operationalize the P&G planning procedures for the unique challenges of environmental projects. This framework is a product of the COE Evaluation of Environmental Investments Research Program (EEIRP).

Response to the Challenge

All COE projects follow the six-step P&G planning process shown in the lower section of Figure 1 that is intended to formulate an optimal (or near optimal) plan to efficiently and effectively address water resource problems and opportunities. These planning steps have proven effective as a framework for planning COE water resource development activities for decades. However, there is generally a lack of standard methods and techniques within the COE planning community to operationalize the P&G framework for assessing the efficiency and effectiveness of investments in environmental restoration, protection, and mitigation. To address this challenge, the EEIRP was designed to develop analytical methods and models for such issues as determining environmental objectives, measuring outputs, and assessing cost-effectiveness. The broad goals of the EEIRP are to develop analytical tools to assist planners, managers, and regulators in addressing the following two statements which are referred to as the site and portfolio questions, respectively:

1. How can the COE determine which is the most desirable alternative to accomplish given environmental objectives ?

2. How can the COE allocate limited resources among many competing environmental investment decisions?

The overall objective of the operational framework is to ensure the products of the EEIRP are incorporated into the site and portfolio evaluation and selection processes. The end product links EEIRP products and COE restoration planning guidance into the existing P&G six-step process as a procedures overview manual. The approach to the development of the framework is illustrated in Figure 1 and is described in more detail below.

EEIRP Products and Guidance

The EEIRP was a three year research program aimed specifically at addressing the analytical needs of COE planners faced with formulation and evaluation of environmental projects. The program was initiated to retain flexibility in planning individual environmental projects and thereby develop answers for the "site" question. It was also intended to promote consistent and effective methodologies for all COE ecosystem planning and thereby develop strategies to address the "portfolio" question.

The EEIRP was organized according to the following work units: (1) Determining and Describing Environmental Significance; (2) Determining Objectives and Measuring Outputs; (3) Objective Evaluation of Cultural Resources; (4) Engineering Environmental Investments; (5) Cost Effectiveness and Analysis Techniques; (6) Monetary and Other Valuation Techniques; (7) Incorporating Risk and

Uncertainty into Environmental Evaluation; (8) Environmental Databases and Information Management; and (9) Evaluation Framework. The products created under the EEIRP came as reports, software, procedures, and training and spanned physical and social sciences. Some of the products were quantitative in nature while others were more descriptive.

COE environmental guidance includes a mixture of established information from traditional environmental activities and freshly minted regulations, tools, and case studies developed specifically for new ecosystem planning activities. For example, the COE has a long history with the mitigation of adverse environmental effects of its Civil Works projects. As a result, the guidance for these activities are well developed and well known. In contrast, the ecosystem restoration mission of the COE is a relatively new mission, and the associated guidance are still under development.

The current ecosystem restoration guidance is Ecosystem Restoration in the Civil Works Program (EC 1105-2-210). This June 1995 engineering circular provides guidance for ecosystem restoration activities of the Civil Works program. This draft guidance is in effect through June 1997. The purpose of this guidance is to ensure that restoration projects: (1) produce the intended beneficial effects; (2) are cost-effective; and, (3) are consistent with Administration policy.

This EC supports previous guidance on ecosystem restoration. It notes that Civil Works budget guidance assigns funding priority to restoration projects (see EC 11-2-163). As in the case of previous restoration guidance, EC 1105-2-210 emphasizes projects to restore environmental degradation to which a COE project contributed or situations where modification of a COE project can accomplish the restoration most cost-effectively. Emphasis will be placed on engineering measures to achieve the restoration objectives. In addition, hydrologic control, rather than pollution abatement, will be the principal means through which water quality improvements are achieved.

The EEIRP products in conjunction with the new EC will give the planning community fresh and useful guidance and techniques for addressing the COE enhanced environmental mission.

Synthesis of the Framework

In collaboration with the development of tools that serve to better measure environmental project outputs and significance, a focus was provided within the EEIRP to accommodate the special communication, trade-off, and decisionmaking needs surrounding environmental plan formulation. The decision metric that supports traditional COE projects, which is based in economics, does not necessarily apply for environmental projects. The whole idea of value and worth is placed in another decisionmaking paradigm that requires use of innovative trade-off techniques and communication among the stakeholders involved with the projects as illustrated in Figure 1. This section describes the research activities and products that were created to support in light of these needs which constitutes the evaluation framework for environmental projects.

An analysis of previous COE environmental studies has been compiled into a two-volume report

Compilation and Review of Completed Restoration and Mitigation Studies in Developing an Evaluation Framework for Environmental Resources (April 1995). This effort commenced with a workshop of selected COE Headquarter personnel to gather information on what is observed, explained, and desired in the review of environmental restoration project documentation. Ten COE case studies involving recently completed and ongoing restoration and mitigation studies and projects were chosen for interviews with their stake holders. COE planners, analysts, reviewers, and decision makers at all levels, and non-COE study participants including members of other agencies, local sponsors, and interest groups were interviewed. Typical analytical, communication, and decision-making problems encountered, as well as analytical techniques and study processes that were successful, were documented. Also highlighted during these interviews were the planning contexts, political and physical, of environmental projects.

Plan formulation of environmental projects necessarily involves tradeoffs to accommodate the many interests of the project. A second research effort examined alternative trade-off techniques in Trade-Off Analysis for Environmental Projects: An Annotated Bibliography (August 1995). This entailed a literature review and annotated bibliography with the goal of identifying applicable methods for the COE planning process.

An ongoing effort will develop a general protocol for incorporating group process techniques into the planning of environmental projects. This report will identify specific group techniques to be used within the six step planning processes and will appraise group process challenges and opportunities faced by COE planners. The resulting product would be a guide that a planner could use to address typical group process challenges. This effort would be conducted through interviews to COE environmental planners to identify problems in the planning process, explore current responses, and evaluate and test potential improvements.

Another ongoing effort is the development of the Overview Framework Manual for this research program. This manual will serve as a primary "linkage" of individual EEIRP work unit products. Each of the chapters in this manual will include a brief discussion of primary objectives and outputs regarding the six-step planning processes. It will also identify how public involvement and/or trade off analyses can support that step, and most important, make reference to the various EEIRP products that can support activities within that step.

Conclusion

Tools and products that are developed and improved upon, such as those from the EEIRP, greatly support the planning communities' ability to make effective decisions. Environmental projects for the COE can be generally supported by the six step process within the P&G in conjunction with COE guidance. As techniques that support the unique conditions of environmental projects surface, they should be added to the menu of tools available to the planner. A critical attribute of an evaluation framework for environmental projects at this point in time is to recognize that technical tools are in the process of being developed and finalized for practical use. In the meantime, insights on environmental project success and priorities will originate from effective trade-off frameworks and open communication among important project stakeholders.

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Septic System Impacts for the Indian River Lagoon, Florida

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The Indian River Lagoon is known as America's most diverse estuary, hosting more than 4,300 plant and animal species. The Lagoon, which makes up 40 percent of Florida's Atlantic Coast is 156 miles long, extending from just south of Daytona Beach to just north of West Palm Beach.

The Lagoon is threatened by tremendous population growth within its watershed. The population in this region was 300,000 in 1970, is currently estimated at 700,000, and is expected to reach 1,000,000 by the year 2000. Septic system and wastewater plant discharges within the watershed enter the ecosystem through both ground water and surface storm flows. An intricate series of man-made canals stretch throughout the watershed and serve as a conduit for pollutants from the watershed to the Lagoon.

Elevated nutrient levels and low dissolved oxygen levels are observed in several locations throughout the Lagoon. In certain cases, algal blooms have occurred and declines in seagrasses have been observed. Generally, water quality is most significantly degraded during the wet season when storm water inputs are the highest. Septic systems are also suspected to be contributors of nutrients through both ground water inputs and stormflow where hydraulic failures occur.

The primary purpose of this project is to quantify the pollutant loadings from septic and wastewater plant discharges. Analytic methods include both watershed modeling and water quality sampling. This progress report summarizes the results of the preliminary modeling work. The next phase of work will include the identification of case study sites and water quality sampling and analysis. The results of the sampling and analysis will then be used to calibrate the watershed models. Once the models are calibrated they will then be applied to future development scenarios (such as year 2000 population projection and saturation buildout conditions).

The watershed to the Indian River Lagoon measures approximately 1.5 million acres (2,311 square miles) and includes portions of the counties of St. Lucie, Okeechobee, Brevard, Volusia, Martin and Indian River. Land uses are predominantly agricultural and residential with more limited areas of commercial and industrial. Agricultural lands are predominantly in citrus production and occupy the largest portion (250,000 acres or 18 percent) of the watershed. According to agricultural records, there are also 50,984 cows located in the watershed. There are approximately 272,500 residential dwelling units located within the watershed. Approximately 121,500 of these utilize on-site septic systems, the balance (approximately 151,000) on sewer collection systems with sewage treatment plants which discharge to the Lagoon.

A nitrogen loading model was developed and applied to the Indian River Lagoon watershed to estimate relative inputs. Nitrogen was selected for the preliminary modeling for two reasons: (1) it is believed to be responsible for the eutrophic effects (algal blooms and low dissolved oxygen) in the Lagoon; and (2) previous investigations have shown that it can be effectively modeled and predicted (Nelson et al., 1988 and Horsley et al., 1996). The model accounts for all major anthropogenic sources of nitrogen (see Table 1). It incorporates source loading rates and persistence factors which were determined from applicable literature values utilizing as many local references as possible (most importantly for agriculture).

Table 1. Selected nitrogen loading rates by source.

Source	Source Loading Rate (lbs/year)	Persistence	Net Loading Rate (lbs/year)
Sewage (per septic system)	20 - 25	50%	10 - 12.5
Lawn Fertilizers (per lawn)	9	50%	4.5
Agriculture (per acre)	170	5%	8.5
Cows (per animal)	135	38%	51.3

A review of numerous scientific papers about the nitrogen content of septic system effluent indicates that the average is 40-50 mg/liter (Nelson et al., 1988). Assuming an occupancy rate of 2.5 people/dwelling unit and an estimated average sewage flow of 55 gallons/capita, this results in an estimated nitrogen loading rate from sewage of 20-25 pounds of nitrogen/septic system per year. Based upon previous investigations, approximately 50 percent of the nitrogen reaches the underlying ground water, the remainder being lost to the atmosphere via nitrification-denitrification processes which occurs beneath the septic leach field. The preliminary modeling work assumes a 50 percent leach rate for sewage derived nitrogen. Other studies conducted in Florida suggest that lower leaching rates may be associated with septic systems (Ayres Associates, 1993).

Nitrogen loading rates for citrus groves were obtained from a series of field studies conducted by the University of Florida, Institute of Food and Agricultural Sciences at the Agricultural Research Center at Fort Pierce (Calvert et al., 1981). These studies indicate that fertilizer-nitrogen applications were approximately 170 pounds/acre per year and that on the average 6.9 percent of the nitrogen applied leaches to ground water. Under high rainfall/irrigation conditions, higher leaching rates (34 percent) were observed. A nitrogen leaching rate of 5 percent was utilized in the preliminary modeling.

The results of the preliminary model runs are summarized in Table 2. Citrus production is indicated as the largest nitrogen source (33 percent) with cattle (11 percent), septic systems (10 percent) and lawn fertilizers (10 percent) as secondary sources. Direct precipitation to the Lagoon is also expected to be significant compared with these other sources. The relative percentage of nitrogen loading attributable to septic systems is expected to increase with continued population growth in the area.

Table 2. Summary of preliminary nitrogen loading to Lagoon by source.

	(lbs/year)	**(percentage of total)**
Septic Systems	1,437,857	10%
Lawns	1,363,300	10%
Agriculture	4,564,148	33%
Cattle	1,553,0745	11%
Forest	660,535	5%
Treatment Plants	484,474	3%
Road Drainage	1,079,397	8%
Direct Precipitation	2,778,416	20%
TOTAL	13,923,227	100%

The next phase of work will include the installation of monitoring wells and water quality sampling to field-verify the nitrogen loading rates attributable to septic systems. This will be accomplished by selecting a series of case study sites where medium to high density septic systems exist. Specially-designed recapture/monitoring wells will be installed to provide representative ground-water samples downgradient of developed areas and within the drainage area to the Lagoon. The results of these analyses will be used to calibrate the watershed model. Further analyses are also planned to further document the nitrogen inputs from agricultural sources within the watershed.

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Conducting Wasteload Allocations in a Watershed Framework: Real World Problems and Solutions

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Abstract

The Total Maximum Daily Load (TMDL) process of controlling all sources of pollutants has been a key component of a watershed protection approach to water quality control. This paper describes problems that have been routinely encountered when simultaneously considering point and nonpoint sources; and some solutions that were applied to address those problems. The problems include: 1) Compounding of safety factors inherent in toxics wasteload allocation procedures when simultaneously applied to all discharges in a watershed; 2) Difficulty in selection of critical environmental design conditions, because wasteload allocations typically consider drought stream flow while nonpoint source analyses consider high intensity rainfall events; and 3) Difficulties in allocating nonpoint source loads; because of the uncertain effectiveness of controls and lack of regulatory mandate for their implementation. Some solutions have been found to address these problems. Probabilistic modeling techniques (i.e. the EPA DYNTOX model) can be used to simultaneously consider variability in all pollutant loads and define multiple-discharge wasteload allocations. A critical period approach can be used for selecting design conditions when simultaneously considering point and nonpoint sources.

Introduction

The watershed approach provides a rational means for controlling pollutant loadings to waterbodies, as it considers all potential loading sources (point and nonpoint). Recent experience has demonstrated that, although the conceptual approach is sound, existing methodologies for calculating wasteload allocations within a watershed framework are often inadequate because they are based upon decades of experience dealing with "end-of-pipe" controls. In some cases, wasteload allocations developed as part of a watershed approach are more stringent than what would have been required from traditional wasteload allocation modeling techniques. Also, it is still in many cases easier to mandate point source controls than to deal with the uncertainties involved in nonpoint source control. This paper is based upon a range of studies where wasteload allocations were conducted under a watershed framework. Three specific examples are discussed here to illustrate the most common "real world" problems encountered associated with developing TMDLs and permit limits under a watershed strategy. They are: 1) Lehigh River, Pennsylvania; 2) Lake Lanier, Georgia; and 3) Saginaw Bay, Lake Huron.

Lehigh River, Pennsylvania

A series of model simulations was conducted to compare the results of traditional wasteload allocation procedures to a probabilistic approach for multiple discharges in a watershed (Schroeder and Marr, 1995). A steady-state wasteload allocation approach was used to calculate water quality-based effluent limits for copper for four discharges to the Lehigh River in Pennsylvania as part of a basinwide wasteload allocation. Each facility was assumed to simultaneously discharge the 99th percentile copper concentration at its design effluent flow during drought stream flow (7Q10) conditions.

Probabilistic modeling techniques were used to simultaneously consider variability in all pollutant loads and determine limits with a specific, known level of protection,. Probabilistic modeling simulates the entire distribution of receiving water concentrations resulting from continuous discharges, rather than simply a single set of critical conditions. Monte Carlo analysis, a probabilistic modeling method which performs multiple random simulations with inputs based on compiled data records and statistical assumptions, was used to generate a forecasted probability distribution of water quality, rather than a single number. This frequency distribution can be used to determine the specific level of water quality protection provided by a given effluent limit. The EPA-supported probabilistic model DYNTOX was applied for the four discharges to determine effluent limits protective of water quality at the once in three year protection level recommended by EPA.

A comparison of the resulting steady-state and probabilistic limits indicated that the traditional steady-state approach resulted in permit limits that were overly protective by up to 71%, as shown in Figure 1. The conservative assumptions used in the steady-state approach resulted in stringent effluent limitations that departed from the desired once in three year level of protection. Stacking conservative assumption upon conservative assumption for multiple discharges results in over-protection when the design condition approach is applied on a watershed basis. When extended to additional discharges, the design condition approach can result in permit limits that are increasingly more restrictive than necessary.

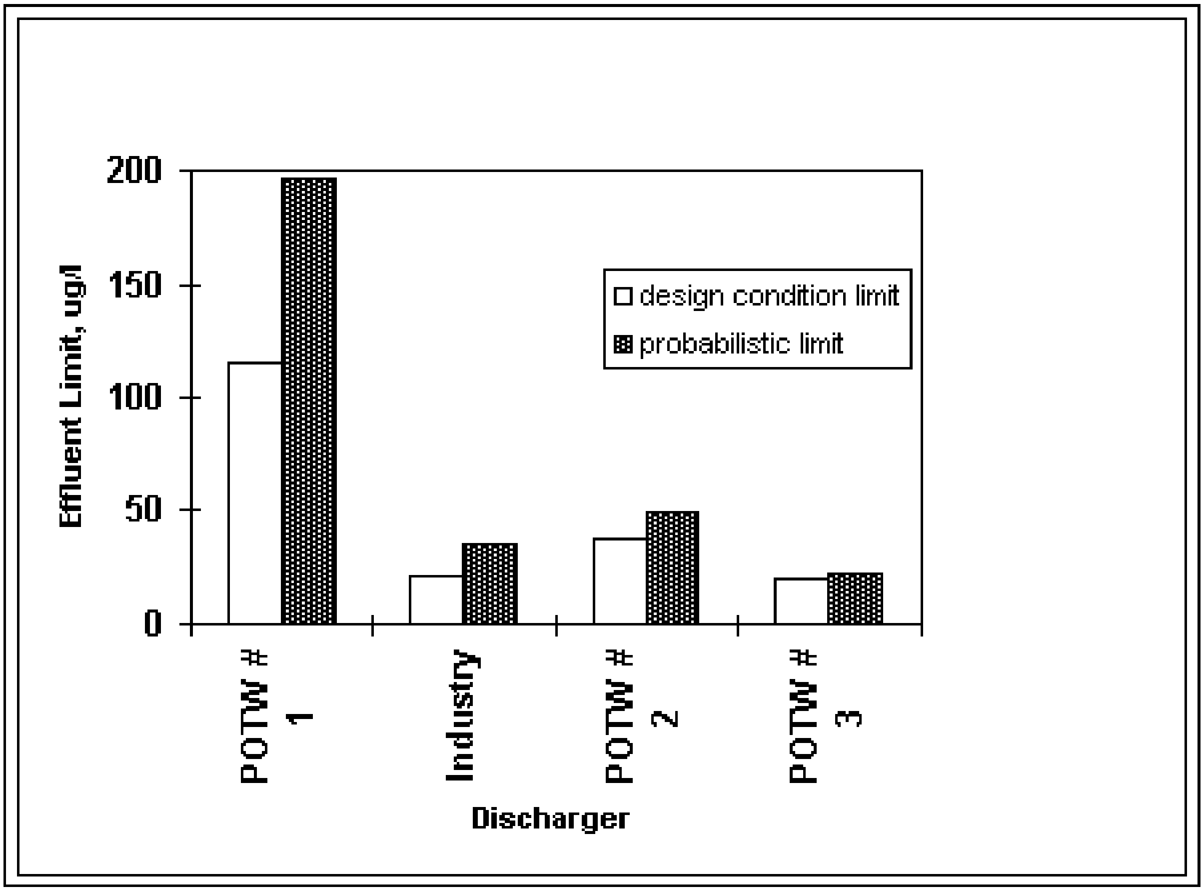

Figure 1. Comparison of Steady-State "Design Condition" and Probabilistic Water Quality-based Effluent Limits for Copper.

Lake Lanier, Georgia

Lake Sidney Lanier is a large multi-purpose reservoir created by Buford Dam on the Chattahoochee River in northern Georgia. The area is experiencing rapid development, which will outgrow existing water supply and wastewater facilities in the basin. Watershed and receiving water quality models are being developed to evaluate a wide range of potential pollutants. These models will be used to predict the future water quality impact of various management scenarios, including construction of a reclaimed water discharge to the lake, as well as nonpoint source controls.

When predicting these future conditions, models require specification of the environmental conditions to be considered. The problems with selection of environmental conditions for watershed modeling are well documented (Dilks and Sweet, 1996). Most management modeling relies upon simulation of a selected subset of critical environmental conditions. A common approach for conducting wasteload allocations as part of a watershed framework has been to assume both drought flow and high intensity rainfall, even when the probability of these situations occurring jointly is zero. This practice can result in technically inaccurate wasteload allocations. An alternative approach is Continuous Simulation, which consists of simulating the entire history of recorded environmental conditions. The primary drawback to the Continuous Simulation approach is that it is very resource intensive. It is not well suited for computationally intensive models that are not amenable to simulating long time periods.

The approach being taken for Lake Lanier balances the resource/information dilemma described above by performing a Continuous Simulation for only a subset of the historical record. It consists of a review of past environmental conditions to identify the occurrence of periods with low assimilative capacity. The intent of the approach is define a subset of years that are expected to contain the most critical periods. For investigating potential point source impacts, these will be the hottest and driest summer seasons, which will maximize residence time and thermal stratification, and result in minimum dilution capacity and maximum potential for algal growth. For nonpoint sources, high flow years may be more critical.

Table 1. Gaged flow into Lake Lanier.

Year	Sum Flow	Percentile
1986	522	100
1957	578	97
1988	595	94
1981	646	92
1985	791	89
1970	883	86
1959	951	83
1982	952	81
1987	1023	78
1989	1051	75
.	.	.
.	.	.
1964	1477	17

1979	**1477**	**14**
1976	**1508**	**11**
1984	**1508**	**8**
1990	**1534**	**6**
1973	**1759**	**3**

The period 1984-1988 was selected as the critical environmental design period for the Lake Lanier study. A statistical analysis was conducted of streamflow and temperature data for Lake Lanier to verify the appropriateness of the 1984-1988 period for this study. Table 1 shows a cumulative ranking of the inflow to Lake Lanier, as represented by the sum of the USGS gaging station flows. Two of the years contained in the critical 1984-1988 period fall in the upper 90th percentile low flow, with 1985 at the 89th percentile. The period also includes an abnormally high flow year, with 1984 representing the 8th percentile. In terms of critical temperatures (Table 2), three years during the 1984-1988 critical period fall in the 90th percentile or above. This same critical period is being used for the Comprehensive Tri-State Study currently being conducted by the U.S. Army Corps of Engineers.

Table 2. Average Summer (Jun - Sept.) Temperature in Atlanta.

Year	Temp. (C)	Percentile
1980	**27.66**	**100**
.	**.**	**.**
1986	**25.98**	**95**
1931	**25.95**	**94**
1987	**25.93**	**93**
1941	**25.85**	**92**

1921	**25.78**	**91**
1981	**25.78**	**90**
1988	**25.75**	**90**
1881	**25.73**	**89**
.	**.**	**.**
1915	**24.73**	**50**
1985	**24.73**	**50**
1907	**24.68**	**49**
.	**.**	**.**
1984	**24.43**	**36**
.	**.**	**.**
1967	**22.10**	**1**

Saginaw Bay, Lake Huron

Saginaw Bay of Lake Huron has been the site of one of the most long term ongoing TMDL-type studies. During the 1960's Saginaw Bay was undergoing severe cultural eutrophication. The most significant ramification was taste and odor and filter-clogging problems at municipal water supplies. Initial efforts to restore water quality in Saginaw Bay were defined in the Great Lakes Water Quality Agreement of 1972, and consisted of categorical limits for phosphorus of 1 mg/l for large municipal treatment plants. Subsequent monitoring indicated that these controls alone would not be sufficient to achieve desirable water quality. The next step was definition of basinwide load reductions required to meet water quality objectives, i.e. the Saginaw Bay "TMDL". Development of the Saginaw Bay TMDL can be described in two steps: 1) defining the total allowable load, and 2) allocating the load among sources.

Allowable phosphorus loads to Saginaw Bay were defined in a three step process: 1) Develop/apply water quality models linking phosphorus load to receiving water quality, 2) Define numeric objectives to support the designated use, and 3) Use model results to define overall load reductions required to meet numeric objectives. A range of water quality models was applied to Saginaw Bay, including a simple total phosphorus model (Chapra, 1977) and a multi-species phytoplankton model specifically predicting noxious blue-green algae densities (Bierman and Dolan, 1976). Numeric water quality standards were not available for phosphorus or algae for Saginaw Bay, so a numeric goal of 15 ug/l for total phosphorus was established based upon a statistical correlation between taste and odor problems and observed blue green algal density. This objective, combined with water quality model results, led to specification of overall allowable loads of 440 metric tons/year.

The modeling effort to define the Saginaw Bay TMDL defined the total allowable load to the system, but did not specify the means to achieve the reduction. Two reduction strategies were proposed: 1) WWTP effluent limits at 1 mg/l and a 55% reduction in nonpoint sources, and 2)WWTP effluent limits at 0.5 mg/l and a 40% reduction in nonpoint sources. EPA's Great Lakes National Program Office subsequently funded a multicomponent study to determine the optimal combination of agricultural and point source reductions (LTI, 1987). The study included an evaluation of the economics of conservation tillage, monitoring of edge of field erosion and loads delivered to Saginaw Bay, and application of nonpoint source models to forecast load reductions due to proposed crop management practices. The economic analysis of the cost of implementing agricultural BMPs indicated that they were the most cost-effective means to achieve the required reductions.

Several agencies (Michigan Dept. of Agriculture, Michigan DNR, MSU Cooperative Extension Service, Soil Conservation Districts, USDA) worked with area farmers to promote the use of conservation tillage and residue management. Significant nonpoint load reductions were achieved, although by 1990 numeric phosphorus objectives had not been clearly met. Several factors contributed to the lack of definitive achievement of loading goals: 1) No enforceable mechanism for nonpoint source reduction equivalent to the NPDES program for point sources, 2) Uncertain effectiveness of nonpoint source controls, and 3) Difficulty in monitoring nonpoint source loads to determine compliance. Figure 2 demonstrates this problem with a comparison of monitored loads to loading goals.

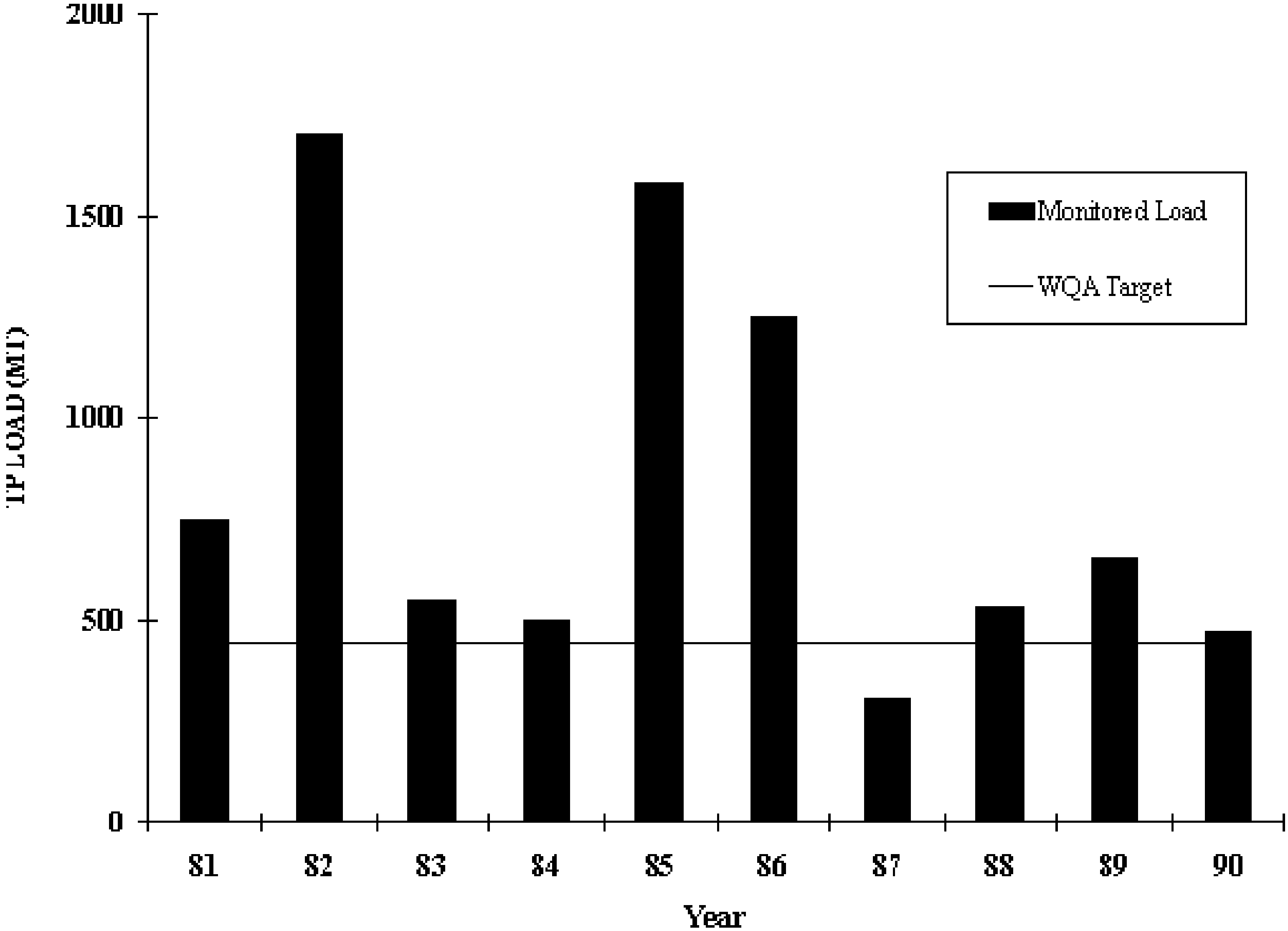

Figure 2. Comparison of Monitored Saignaw Bay Load to Target (from Feist et al, 1993).

Fortunately, the reductions in phosphorus loads that were achieved were sufficient to meet the ultimate water quality objective of removing taste and odor problems (at least temporarily). In the early 1990's, infestation of Saginaw Bay by the exotic zebra mussel disrupted the food web in Saginaw Bay and has led to an apparent competitive advantage of blue green algae. U.S. EPA and Michigan DNR have subsequently funded new modeling studies to: 1) revise the existing multi-species phytoplankton model to include zebra mussels, 2) determine if the altered ecological structure of Saginaw Bay will require a change to the TMDL in order to maintain compliance with water quality objectives (LTI, 1995).

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Nonpoint Source Management System Software: A Tool for Tracking Water Quality and Land Treatment

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***Web Note:** Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

Background

Nonpoint source watershed projects present analysts with significant challenges in data management and analysis due to the need to track land-based activities, precipitation, water quantity, and water quality. Much has been invested by some in developing geographic information systems, large water quality data bases such as the U.S. Environmental Protection Agency's (EPA) STORET, and high-powered statistical analysis packages. Watershed projects, however, still need compact, user-friendly, software packages that handle both land management and water quality information.

This paper describes the NonPoint Source Management System (NPSMS), a software package developed by EPA for watershed projects funded under section 319 of the Clean Water Act (CWA).

Section 319 National Monitoring Program

EPA annually awards CWA grants to support state implementation of nonpoint source (NPS) control programs. EPA initiated the National Monitoring Program (NMP) to address its need to report on section 319 program implementation, progress made in reducing pollution from nonpoint sources, and water quality improvements resulting from program implementation (EPA, 1991a). EPA specified monitoring protocols for NMP projects to provide a consistent, minimum set of water quality and land treatment data that would support a national evaluation (EPA, 1991b). There are currently 15 approved NMP projects, with others under development. The NMP has been described in greater detail elsewhere (Dressing, et al., 1994; EPA, 1994; Osmond, et al., 1995).

NPSMS

EPA developed NPSMS to help NMP projects track and report land management and water quality information. NPSMS has three data files: (1) the Management File which includes information regarding water quality problems within the project area and plans to address those problems; (2) the Monitoring Plan File which includes the monitoring designs, stations, and parameters; and (3) the Annual Report File which contains annual implementation and water quality data (Figure 1).

Early versions of NPSMS operated in a DOSTM environment. Version (4.0) requires an IBM AT class of computer, preferably a 486 or better, running MS WindowsTM Version 3.1 or better (EPA, 1996). Other requirements are 640 kilobytes of RAM, no more than 5 megabytes on the hard drive, and a floppy drive. Users will prefer an EGA, VGA, or SVGA color monitor, and a color printer for graphics.

Management File

The Management File contains information on the watershed, or management area, including location, drainage area, waterbodies, water quality problems, pollutants causing identified water quality problems, and pollutant sources. The Management File also contains information regarding the best management practices (BMPs) or control measures that will be used to address the water quality problems, the specific sources and pollutants to be addressed by each BMP, and the implementation goals for each BMP. Project funding is also recorded in the Management File, with data fields for funding uses, sources, and annual expenditures.

Monitoring Plan File

This file describes the monitoring designs used to evaluate the watershed project. NPSMS supports three basic designs: (1) paired-watershed (Clausen and Spooner, 1993), (2) upstream-downstream, and (3) single-station. Chemical, physical, biological, and habitat data can be entered into NPSMS. Users first identify the type of data to be collected, and then select the paired-watershed, upstream-downstream, or single-station study design. Monitoring stations are then identified with a name and STORET agency and station codes. The drainage area for each monitoring station is then entered, along with land use, monitoring parameters, monitoring seasons, and information regarding quality assurance and quality control.

NMP projects enter raw water quality data into STORET, BIOS, or WATSTORE. Raw chemical/physical data are also converted to quartile counts for entry into NPSMS (Dressing, et al., 1994). Quartiles for each monitored parameter are determined from the frequency distribution of data collected prior to implementation of BMPs, and data for any given season are reduced to the number of samples whose parameter values fall within each quartile. EPA will test for trends in the distribution of quartile counts as one measure of whether water quality has improved (NCSU, 1989). For biological/habitat monitoring, seasonal mean community or index values are entered into NPSMS and compared against the maximum potential score of close-ended indices such as the index of biotic integrity (Karr, 1981) or the estimated highest possible score for an open-ended index such as the index of well being (Gammon, 1980). Seasonal means are also compared against reasonable attainment scores and scores at which designated beneficial uses are fully supported, threatened, and partially supported.

NPSMS was structured around grab sampling for chemical/physical data since the NMP does not require expensive storm-event sampling. Coupled with the focus on quartile counts, this restriction on sampling method severely limited the applicability of NPSMS beyond the NMP. EPA modified NPSMS to handle storm-event data since several NMP projects include storm-event monitoring.

Users have two options for entering storm-event data. The simplest approach is to record the data in quartile format as is done with grab-sampled chemical/physical data. Weekly load estimates derived from composite samples would be converted to quartile counts with this approach. The more detailed option is to enter discharge, weather, and water quality data for each sampled storm event. Storms are identified by an event number. Sample collector, composite method and medium, and the time and discharge represented by the composite sample are recorded. Weather information includes precipitation sampling method, sample collection date and time, time represented by the sample, total precipitation amount, five-day precipitation (for antecedent moisture), average snow cover, and air temperature.

With the storm-event option, NPSMS can now support a much broader range of watershed projects since it is no longer explicitly linked to the quartile approach used in the NMP. By altering the composite method specified (e.g., grab sampling or weekly flow-weighted), users can apply NPSMS to a wide range of sampling scenarios.

Annual Report File

This file receives annual BMP implementation and water quality data. Implementation data can be reported either as annual or cumulative implementation, and progress can be measured against the goals set forth in the Management File. For example, acreage of cropland under nutrient management would be reported as annual implementation, whereas the acreage served by stormwater management structures would probably be reported as cumulative implementation. Water quality data are entered as quartile counts for chemical/physical grab-samples, as quartile counts or raw data for composite storm-event samples, or as seasonal mean community or index scores for biological/habitat monitoring.

Graphics and Other Features

NPSMS includes several standard reports and graphics. Users can easily display all data in a logical, formatted report. Reports can be generated for all or selected management areas and monitoring stations. Version 4.0 graphics provide the user with enhanced capabilities for creating and editing charts and plots for display or color printing. High-resolution graphics can be displayed on a standard PC with an EGA or VGA monitor.

NPSMS has a data export option which is used by states to report to EPA. It can also be used to create input for advanced statistical analyses using packages such as SASTM.

Future Directions

Ground Water, Lakes, and Estuaries

NPSMS currently handles only stream studies, but future versions will accommodate ground-water, lake, and estuary studies. To address these study types, a depth field will be added to the monitoring station. NPSMS will also be adapted to allow users to specify distinct recharge areas which may differ from the drainage areas delineated for surface monitoring in the same study area.

User-Guided Analyses

Version 4.0 restricts opportunities for comparing data from one station with data from other stations due to its explicit linkage of stations when monitoring designs are selected. Currently, data from control sites can only be plotted against data from the study sites in paired stations, and a similar limitation applies to data from upstream-downstream studies.

In the future, NPSMS will allow the user to select the stations from which data will be compared and plotted. This is essential to the analysis of ground-water data derived from nested wells that extract samples at different depths. Similarly, lake and estuary sampling is often conducted at different depths, and analysts may be interested in comparing data from one depth at one station with data collected at the same or different depth at another station.

Linkage to Other EPA Data Bases

NPSMS is designed for linkage with other EPA data systems, including the section 305(b) Waterbody System, River Reach File (RF3), and STORET. While direct linkages are not now available, the use in

NPSMS of section 305(b) waterbody identification numbers and use support codes, STORET station and agency codes, STORET parameter codes, and latitude/longitude coordinates provides opportunities for establishing such linkages.

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Watershed LOJIC -- A Logical Approach to Stormwater Management and Permitting

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Web Note: *Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

Introduction

The Louisville and Jefferson County Metropolitan Sewer District (MSD) has been involved in wastewater management since 1946. In 1987 MSD embarked on a new venture; the development of a utility to fund the stormwater operations in Louisville and Jefferson County. At the same time MSD also led the initiative to develop a countywide Geographic Information System(GIS). A countywide information organization called Louisville and Jefferson County Information Consortium (LOJIC) was created. LOJIC represents a multi-agency effort to build a comprehensive geographic information system. Participants include the City of Louisville, Jefferson County, MSD, and the Property Valuation Administrator (PVA).

Comprehensive, countywide management efforts can only be accomplished with a well organized, watershed approach and the integrated management tool of GIS. This paper describes how MSD has used LOJIC as a primary tool to develop the stormwater program and manage the community's KPDES stormwater permit.

Jefferson County Watersheds

There are 11 major watersheds within the boundaries of Jefferson County, Mill Creek, Pond Creek, South Fork Beargrass Creek, Middle Fork Beargrass Creek, Muddy Fork Beargrass Creek, Cedar Creek, Pennsylvania Run, Goose Creek, Harrods Creek, Ohio River and Floyd's Fork. The Ohio River watershed is primarily served by a combined sewer area. Mill Creek and Pond Creek are located in Western Jefferson County and are characterized by wide flat floodplains and topography. The three Beargrass Creek watersheds are located in Eastern Jefferson County and are almost fully developed. The eastern portion of Jefferson County is characterized by narrow floodplains, sloping topography and have a high potential for flash flooding and are undergoing a rapid rate of development.

Watershed Management

Through its own efforts, cooperative efforts with the United States Geological Survey (USGS), and coordination with the County's Comprehensive Plan Update, MSD is developing a watershed_based approach to management of its activities and responsibilities. The pilot work conducted by MSD in the Cedar Creek watershed, along with the Multi_Objective Stream Corridor/Greenway Plan, is defining the policy by which MSD will plan capital projects and review and approve development from a water quantity (floodplain and floodway) standpoint. A cooperative effort with USGS to model and monitor water quality in the Beargrass Creek Watershed is being used to define the policy by which MSD will plan capital projects and review and approve development from a water quality standpoint. A unified policy on watershed management is currently being drafted by the stormwater planning staff. The following paragraphs are brief descriptions of the programs that make up the watershed effort of Jefferson County.

Stream Outfall and Structure Inventory Program

Through a joint venture between MSD, the Louisville Chamber of Commerce and Jefferson County Public Schools, the discovery and field screening of stormwater outfalls in five watersheds were conducted in the summers of 1993, '94 and '95. The students while walking the creeks and recording the outfall data, have also taken photographs of the creek and reported on erosion and condition of channel banks. The participation of high school students in the field teams generated public interest and awareness of water quantity and quality problems as well as the value of natural and beneficial function of streams and channels. MSD is systematically following up problems discovered in these projects by evaluating potential problem outfalls and requiring improper connections to be disconnected.

Comprehensive Planning Coordination

Cornerstone 2020, the Comprehensive Plan Update for Jefferson County, is a monumental effort which involves a majority of the local government agencies and utility companies. This effort is changing the way land use planning is conducted, and will therefore directly impact the future quality of stormwater and streams in Jefferson County. Three specific items which will impact water quality are the Multi-use Stream Corridor/Greenway Plan, the Soil Erosion and Sediment Control Ordinance and the revised Floodplain Ordinance. The Greenway Plan has been adopted as part of Cornerstone 2020. Both the Soil Erosion and Sediment Control and revised Floodplain Ordinances are currently being developed and will be adopted in 1996.

Greenways

The Multi-Objective Stream Corridor/Greenway Master Plan for Louisville and Jefferson County was completed in March, 1995. The plan describes the activities for the next 10 years that are necessary for the development of a successful program. The plan has been adopted as part of Jefferson County's comprehensive plan update. One of the early actions involves creating a Greenways Commission and a full-time Greenways Manager position. These individuals will be responsible for administering the implementation of the plan. Some of the primary goals of the plan are to provide benefits to water quality, flood control, recreation, alternative transportation and plant and animal habitat.

Cedar Creek Watershed Project

MSD has started the comprehensive watershed based master planning process by completing a pilot study in 1994 on the Cedar Creek basin. The purpose of the pilot study was to identify and develop solutions for water quantity problems, to begin to assess stormwater quality, and to incorporate the hydrologic and hydraulic computations and work products into LOJIC. The key elements developed in the Pilot Basin Study and recommended for future master planning efforts are the use of structural and non-structural water quantity management measures, environmental quality management measures, a public involvement program and plan implementation.

FEMA Floodplain Mapping and Community Rating System (CRS)

MSD, in cooperation with FEMA, has digitized the Jefferson County Flood Insurance Rate Maps (FIRMs) into the GIS and obtained their approval by the Federal Emergency Management Agency (FEMA) as the definitive floodplain maps for the county. MSD is now evaluating the need for map corrections, additions, and revisions, and is exploring ways to accelerate the revision process by using GIS technology.

MSD participates in the Community Rating System of the Federal Emergency Management Agency's National Flood Insurance Program which rewards communities with floodplain management programs that surpass minimum requirements. The City and the County currently hold Class 7 ratings, which entitle floodplain residents with flood insurance policies to a 15% reduction in premiums. The communities have submitted applications to reach Class 6 ratings. Only two communities in the United States currently hold ratings better (lower) than Class 7.

Stormwater Permit Report

MSD submitted the Year 2 KPDES Stormwater Permit Report in February 1996. This document reported on the progress and issues with regard to the stormwater quality management in Jefferson county in 1995. Figure 1 shows one of the watershed maps submitted in the Year 2 report. This map is an example of the watershed approach that this community is pursuing in both water quantity and water quality. For example the Hazardous Material Areas are shown as orange triangles on the map.

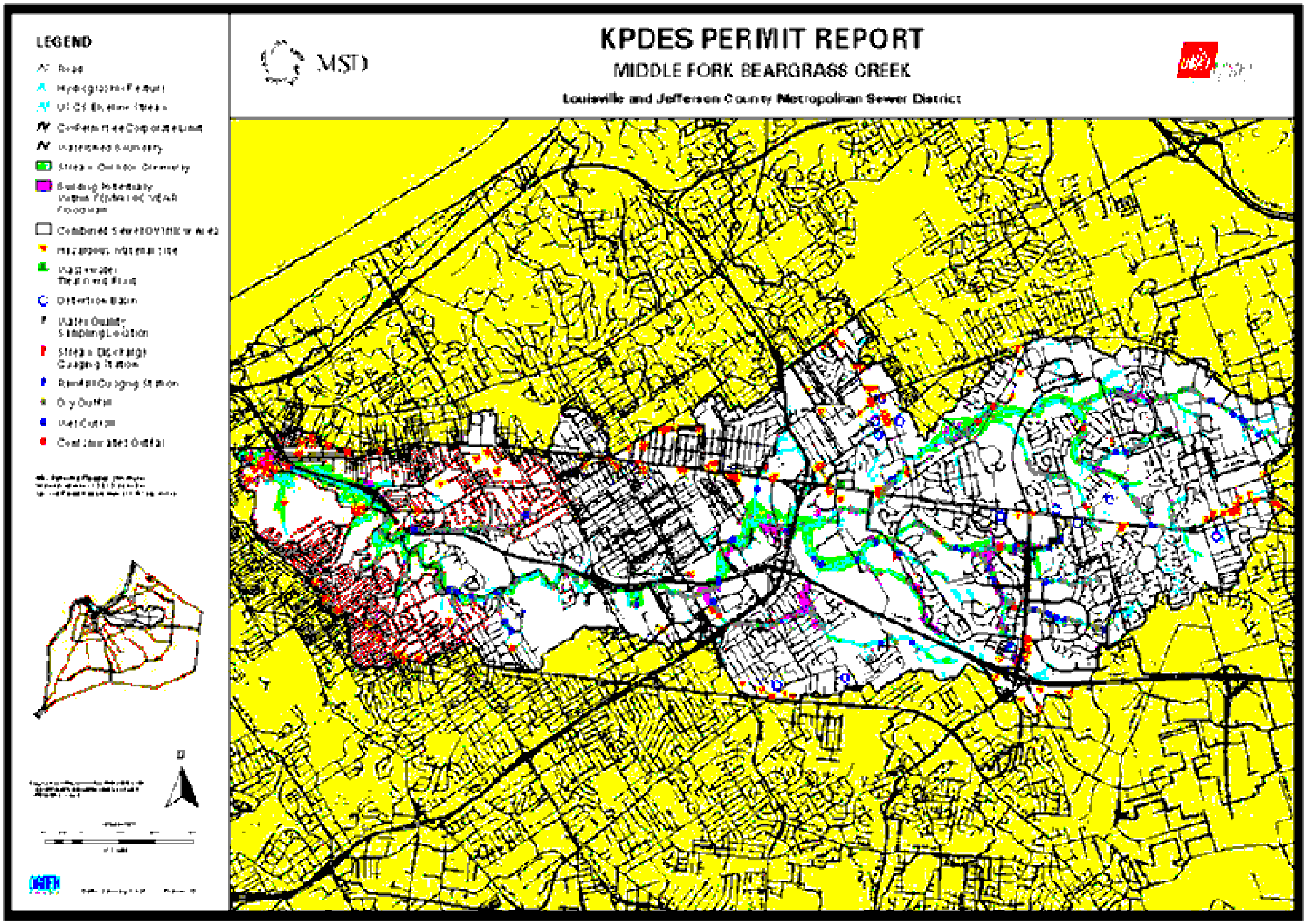

Figure 1. KPDES Permit Report.

Each of the triangles have a database attached that describe the location of the site, the nature and type of materials stored at the site and persons in responsible charge. This information and the power of GIS can be used to assess and trace pollutant discharges as well as manage emergency situations. In addition to the watershed maps a GIS (LOJIC) file was developed that contains critical information in an interactive format that can be easily accessed and maintained. The watershed summary sheets shown in Figure 2 also show the type of information available for each watershed. As MSD moves to a watershed based program additional information and applications will be developed and LOJIC will used as the management tool.

ACRONYMS

MSD	Metropolitan Sewer District
GIS	Geographical Information System
LOJIC	Louisville and Jefferson County Information Consortium
CSO	Combined Sewer Overflows
PVA	Property Valuation Administrator
FIRMs	Flood Insurance Rate Maps
FEMA	Federal Emergency Management Agency
KPDES	Kentucky Pollution Discharge Elimination System
USGS	United States Geological Survey
SQTF	Stormwater Quality Task Force
CRS	Community Rating System

EPA Environmental Protection Agency

City of Los Angeles_Stormwater Information Management System

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Over the past two decades, local, regional, and national-scale research programs have shown that pollutants discharged from municipal separate storm sewer systems are among the principal causes of water quality problems in most urban areas. Recognizing this, Congress and USEPA set forth legislation and regulations (respective) that have required public works managers in most sizeable urban areas to focus attention on their storm water collection and conveyance systems. The regulations were intended to get senior management personnel engaged in efforts to consider the following:

- What are the physical characteristics of our storm water system?
- Where does it discharge to the local receiving waters?
- What land uses and activities are served by the system (and contribute pollutants)?
- What degree of control do we have over those who contribute pollutants?

- What concentrations and annual loads of pollutants are discharged with our storm water?

- What do we presently do to minimize those pollutants and their resultant impacts?

For most sizeable municipal public works departments and flood control agencies, the past several of years' efforts to respond to NPDES permitting requirements have been challenging and illuminating; but also frustrating. Most applicants learned things about their systems that will help them be better managers in the future. Most of these applicants are now facing the lack of practical ways to effectively conceptualize and manage large, complex urban watersheds. To do so will require managers to collect and consider large amounts of diverse information on a continuing basis.

The City of Los Angeles contains two large and complex urban watersheds. The Santa Monica Bay watershed is a highly urbanized area draining to a highly popular bay which supports many beneficial uses including recreation, shellfish harvesting and fish consumption. The Los Angeles River watershed is also highly urbanized and is additionally burden by the discharges from several treatment plants.

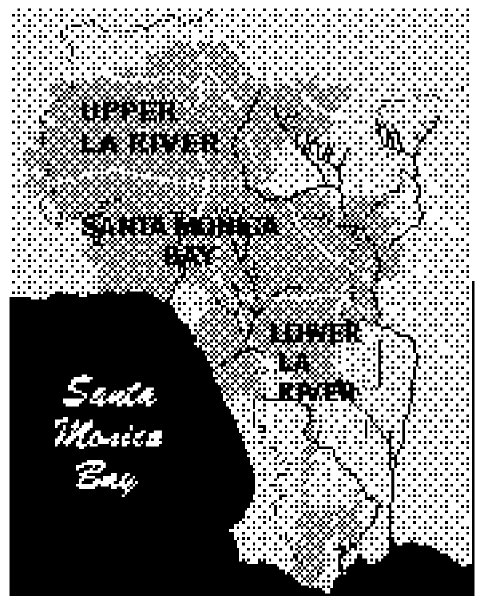

Figure 1. Watershed Map.

In order to effectively manage the ongoing collection of data, the City has chosen to develop a Stormwater Management Information System that is built around a Geographic Information System (GIS). This Stormwater Information Management System has many uses and components. Not only is the system used to track and report on current NPDES permit activities, it helps predict water quality throughout the City's extensive storm drain network. Ultimately, both maintenance personnel and drainage system inspectors will have a direct link back to the Information System for use in tracing and recording pollution problems in the field. The system will also track polluters and violations that have been identified. The GIS provides a basis for comparing the geographic patterns of probable pollutant sources, observed pollution problems, actual management efforts (e.g. structural and non-structural Best Managment Practices (BMPs)), and spending patterns for pollution controls. Associated databases will be used to store monitoring data, to facilitate periodic compliance reporting, and to develop information for public education and outreach programs. In concert with this development is the availability of this and other drainage information via the Internet along with interactive public involvement.

Stormwater Information Management System

The City of Los Angeles' Stormwater Management Division is organized into 6 sections; permit compliance, financial, engineering, public education, inspection, and monitoring. The mission of this division is to implement and manage programs that ensure City compliance with Federal, State, and local flood control and stormwater pollution abatement laws and regulations; to develop programs that ensure that storm drain discharges do not interfere with the beneficial uses of the City's receiving waters. The Stormwater Information Management System is designed to respond to both the stormwater pollution regulations and the City's flood control responsibilities.

The design of the information management system stemmed from numerous workshops and meetings with each section. These interactions resulted in a conceptual database design and 12 targeted applications. Top management assigned priorities to each of the 12 applications and common data sets were identified. The common data sets identified were: (1) street network, (2) parcels, (3) storm drain conveyance system, (4) land use, (5) hydrologic boundaries (watershed and sub-areas) and (6) jurisdictional boundaries. The 12 prioritized applications were: (1) water quality model, (2) enhanced catch basin cleaning tracking, (3) catch basin stenciling tracking and reporting, (4) flood zone inquiry, (5) FEMA flood plain map revision tracking, (6) repetitive flood loss tracking, (7) school education program reporting, (8) BMP reporting by council district, (9) corporate sponsor tracking, (10) stormwater pollution abatement charge tracking, (11) industrial site investigation tracking and reporting, (12) pollution investigation trace.

Water Quality Model

There are numerous approaches to modeling of pollutant loads. These range from statistically-based (so-called "spreadsheet") models to complicated physically-based models (e.g. SWMM, HSPF) which attempt to simulate complex series of actual physical mechanisms (from pollutant accumulation to wash-off to transport within the storm water collection and conveyance system). There are many pollutant sources which make it difficult to use complex physically-based models to derive pollutant concentrations arising from the many activities associated with land uses and other sources. In almost all actual urban areas, there is simply not enough reliable field information to properly calibrate the very complex models, so that all of the important source categories will be accounted for. Often, one or two mechanisms (e.g., build-up/wash-off) are given too much emphasis and are used to account for a very broad range of fundamentally different sources and mechanisms. Furthermore, the models seldom account for other sources that are known to be very important (e.g., illicit connections, illegal dumping, leaching of pollutants). Many of these models, therefore, tend to over-predict the potential performance of control measures (such as street sweeping) which involve removing the built-up dry-fall particulates on surfaces .

It is for these reasons, that the City of Los Angeles decided to begin with the use of straightforward, statistically-based models to estimate and predict runoff quality from urban environments. It should be noted that EPA has supported and will probably continue to support a considerable series of research and development efforts to advance the state of the art of storm water modeling. At some future time (if specific information needs are important enough to justify the time and expense of supporting sophisticated models with adequate field-derived data), more complex physically-based methodologies may be applied to the City's needs.

The Water Quality Model takes available rainfall data for a given storm event (from Weather Service records or local rain gauge readings), applies a basin-specific rainfall/runoff computation to estimate the runoff volume, and multiply this volume by a seasonally adjusted pollutant concentration coefficient to compute the pollutant load from the given basin. This process is repeated using different concentration coefficients for each pollutant of concern. The total load of a given pollutant from a given event is calculated by summing up the basin-by-basin loads for all basins that are tributary to (i.e., up-gradient from) the location of interest. The annual loads for a given pollutant are calculated by summing up the loads for all events in the year. A seasonal variation in the pollutant coefficient helps to account for the typical summertime buildup of pollutants. The generic equation is of the form:

Yp = SKMapXa

where:

Yp is the calculated total pollutant load for pollutant "p"

K is a seasonal adjustment coefficient

Map is the estimated pollutant concentration for land use "a", pollutant "p"

Xa is the estimated runoff volume generated from land use "a"

S is the summation over all land uses in the watershed

This methodology is similar to the methodology developed under the EPA's Nationwide Urban Runoff Program (EPA 1983) and recommended by EPA for use in municipal NPDES programs. The methodology makes good use of (where available) local data for rainfall, land use, and drainage area characteristics, and, if available, local water quality data.

The water quality model operates completely within the GIS environment. It uses the processing power of the GIS to retrieve, format and prepare the necessary rainfall, land use, soils and other information for the drainage area under study. The model allows for 4 preset rainfall events plus 2 user specified events, and the selection of up to 27 different pollutants to model. "What if" analyses can be done by changing land uses, pollutant coefficients and time of year.

A pilot project to demonstrate the functionality of the water quality model was completed over a 25 square mile area in early 1995. The model was tested and reviewed by City staff and comments and requests for changes and enhancements were compiled. The final model was completed in December 1995.

Application Development

Many of the other applications have been completed and are in operation. Three noteworthy ones are discussed here in more detail. The Enhanced Catch Basin Cleaning application helps to analyze and visualize a pilot project involving a rigorous and regular cleaning of some 1000 catch basins in three distinct drainage areas of the city. The application allows easy retrieval and analysis of the data including total paper, soil, plastic, and toxics by catch basin, by cleaning route and by drainage area. In addition the GIS reports on the land use breakdown of each of the tributary drainage areas. This data is being used to develop an understanding of any correlation between land use and the debris removed from the catch basins. This understanding will then feed public awareness efforts and maintenance scheduling over the remainder of the City.

The Flood Zone Inquiry allows the Stormwater Management Division staff to determine the flooding potential of any parcel in the City. Previously any request would require staff to gather both City and FEMA maps, manually overlay the two, make a determination, produce a composite map and letter to be sent to the requesting party. In this application the uses enters the requesting party's name,the subject parcel address and the City staff person's name is entered and the GIS automatically generates a letter sized map of the property and a properly addressed and formatted letter. The manual process required approximately 2 hours of effort and usually occurred over two days. This application reduces this process to less than 5 minutes, thereby saving a great deal of time annually.

The pollutant investigation trace utilizes many of the capabilities of the water quality model. This application helps to target sources of pollutants within a given watershed. A user selects the outfall or other storm drain location in the city and enters the pollutant of concern. The application determines the extent of the drainage area to the selected location and then compares the selected pollutant to the Standard Industrial Classifications (SIC) of each of the parcels within the drainage area. A table developed by the Stormwater Management Divisions' inspection and monitoring sections is used to relate the parcel's SIC to possible pollutants. A map showing the parcels with matching pollutant source is created. A report delineating other information management system information about each parcel is also created. This report outlines any inspection history, enforcement actions, illegal dumping, or other information that may be helpful in determining the source of the pollution. Management is able to deal with real-time problems with a much more structured and targeted process.

Public Access to Information

In keeping with the City of Los Angeles' mission to better serve its citizens and the Mayor's intentions to capitalize on technology, the Stormwater Management Division has committed to an intense use of the Internet through the use of the World Wide Web. This use is twofold, first to provide information about the stormwater program and what the citizens can do, and secondly to provide a vehicle for communication from the public at large.

Information available from the Stormwater Management Division is comprised of information about flood control and stormwater pollution abatement activities. Flood control information includes areas on the history and development of the flood control system within the Los Angeles area, maps showing the major drainage systems and watersheds, information about FEMA and flood insurance, and the ability to access the flood zone inquiry application so that anyone can evaluate the flood potential of any parcel in the City. There are numbers of forms to request service or report problems including catch basin cleaning and areas of flooding. These forms are then automatically forwarded to the appropriate staff in the City for action.

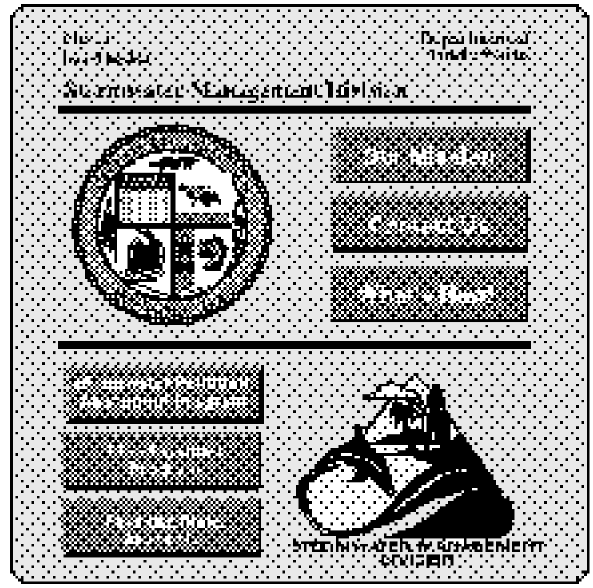

Figure 2. Home Page Design.

The stormwater pollution abatement activities contains areas that describe the overall program that the City has underway. Information details the status of the program, extensive information from the public education section about what every citizen can do to help cleanup the urban stormwater, and links to EPA and other related sites for additional stormwater pollution abatement information. Forms are available here as well to request information to be mailed, request a speaker for an event, fill out permits and request general assistance.

All of the incoming requests are gathered and reported back as part of the overall management information system. This data helps Stormwater management understand where issues or problems are occurring and is used to help schedule staff assignments and the budgeting of expenditures of resources.

Future Planned Developments

The creation of the Stormwater Information Management System over the last 2 years has provided an eye-opening environment to other possible extensions and uses. Efforts are currently underway to define and prioritize these added features. All of the features share the common goal of providing management information that will lead to better decisions about the expenditure of time and money in addressing stormwater quality and quantity in the City. Additionally, the system is be used extensively in managing the implementation of a re-newed NPDES permit (expected in late 1996) in the areas of industrial site investigations, enforcement actions, and city corporation yard management. Some of the other future expansion features are:

1. Field automation_stormwater field inspectors will carry a hand-held pen-based computer. This computer will have city-wide maps of the storm drain system, GPS capabilities to track location and forms to fill out during investigations. The system will also include the ability to search industrial users within each watershed. Management will be able to quickly react to current field situations and activities.

2. Advanced water quality model features_additional and better monitoring data from the Los Angeles area will provide the opportunity to add advanced features to the model. These features include preliminary BMP selection and potential benefits, dry-weather flow predictions and

adjustments to the seasonality and event mean coefficients. These enhancements will allow the stormwater engineers to better understand of the working of each watershed and management to make more informed and better decisions.

3. Operations and maintenance history_stormwater engineers need to understand the maintenance efforts and results of maintenance operations. The information gathered by other departments will be made available on a system element (pipe, catch basin, debris basin) basis. The long term history of maintenance efforts will lead to better decisions about future improvements to the system as well as better management practices.

4. Ultimate system configuration_the management system will track the ultimate system designs and locations. This will assist stormwater engineers in planning the development and improvement of the system, help the public education section develop materials explaining the changes and enhancements to water quality, and provide management with the budgeting and prioritization of improvement information.

Conclusions

The development of a Stormwater Information Management System has provided stormwater managers the opportunity to define their need for information to make better and more informed decisions. The collecting, organizing, retrieving and querying of historical data is critical to a stormwater program manager. Over time, understanding temporal and spatial patterns, where money has been spent, the effect of that expenditure on water quality, maintenance activities, public awareness or political realities will become more apparent. The capture and tracking of this information also helps to bridge the organizational realities of a large municipality. A properly designed and utilized information management system can help transcend the movement of management staff between departments that typically carries with it a loss of institutional memory.

The art and science of stormwater quality is still in infancy. The City of Los Angeles has decided to build a state-of-the-art system to begin to understand the larger, long-term picture of stormwater quality within its watersheds. The initial step has addressed short term needs and provided the desi gn for the development of the long term system. The future growth will provide managers with the long term information to manage and improve a complex urban watershed well into the 21st century.

Spatial Modeling of Aquatic Biocriteria Relative to Riparian and Upland Characteristics

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***Web Note:** Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

Introduction

Riparian zones can be viewed as a boundary, or ecotone, that affects the cascade of water, energy, sediment, nutrients, and molecules between land and water, and within the stream itself (Risser, 1990). Riparian zones have significant effects on both chemical and physical factors such as light, temperature, dissolved oxygen, suspended solids, dissolved ions and other materials that play critical roles in determining an area's suitability for aquatic organisms. The health of aquatic biota is an important barometer of how effectively environmental goals are being achieved. Biological criteria are direct measures of aquatic ecosystem condition and are based on measurable characteristics of aquatic communities such as species richness, key taxonomic groupings, functional feeding guilds, environmental tolerance, and evidence of stress (Yoder and Rankin, 1995). Ohio EPA compared the sensitivity of aquatic biota as a measure of environmental impairment to currently accepted assessment methods. The comparison showed that biological impairment was evident in 49.8 percent of the segments where no ambient chemical water quality criteria exceedences were observed (Yoder, 1991). Both the biological and chemical assessments agreed on impairment (or lack thereof) in 47.4 percent of waterbody segments. These findings suggest the ability of biota to detect impairment in the absence of chemical exceedences (Yoder, 1991).

The objectives of this study are: (1) to determine patterns of riparian conditions which are beneficial for instream biological integrity; (2) to characterize watershed stressor and modifier components in a digital geographic information system (GIS); and (3) to determine the significance of impacts from upland stressors relative to characteristics of riparian modifiers.

The analysis employed will result in a predictive spatial model that could benefit the preparation of state-wide water quality summaries like those required under section 305(b) of the U.S. Clean Water Act (P.L. 95 -217). Assessed waters are those for which a state is able to make use support decisions and includes both "evaluated waters" and "monitored waters." Using this modeling approach in a predictive mode could potentially increase the number of "evaluated waters" included in a state's 305(b) assessment. Further, determination of the relative significance of environmental stressors for a given watershed can be used to aid in prioritization of stressors as part of the watershed protection approach (U.S. EPA, 1995). An objective method for prioritization could assist in problem identification for "stakeholders" in specific watersheds.

Model Description

Big Darby Creek watershed is located in west-central Ohio within the Eastern Cornbelt Plains ecoregion. The watershed drainage area is approximately 1500 square kilometers. The Darby system contains biological diversity that is exceptional compared to other streams of a similar size located within the ecoregion. This study area was chosen because land use is dominated by agricultural production with urban stresses comparatively minor and localized. This configuration of land uses allows the modification effects of riparian ecotone conditions to be evaluated in the context of primarily agricultural stressors.

The entire Darby Creek watershed was discretized into 51 subbasins in the GIS Arc/Info. Subbasin outlets were determined by the location of sampling sites for the Index of Biotic Integrity (IBI; Karr, 1981), a measure of instream biotic integrity used in the establishment of biological criteria (Figure 1). The IBI is a multi-metric index of fish community health that measures species richness and composition, trophic composition, and fish abundance and condition. The index ranges in value from 12 to 60, with 60 being a perfect score.

A predictive model of the relationship between riparian and upland characteristics and biotic integrity was built using ordinary least-squares regression. The regression model will be of the form:

$$R_{ij} = b_0 + b_1 * s_{1j} + b_2 * s_{2j} + \ldots b_n * s_{nj} + e_{ij} \quad (1)$$

where,

Rij is a biological monitoring value, i, (e.g., Index of Biotic Integrity or one of its components) at a specific stream location j (j = 0);

bn are ordinary least-squares linear regression coefficients;

snj are explanatory variables for various types of stressors and modifiers located upstream of the specified stream location j; and

eij represents normally distributed model error.

The response variable in this study was the IBI score measured at subbasin outlets. Riparian predictor variables include metrics for five vegetative cover types considered indicators of riparian conditions: forest, shrub/brush, grass, cropland, and urban. The predictor variables are derived from the following riparian and upland characteristics:

- Patch variables_mean width (m), proportion of total area, proportion of stream length bordered, proportion of stream length bordered under 24 m in width, mean perimeter-area ratio, and the product of mean perimeter-area ratio and patch length.

- Run variables_mean run length and mean run density.

- Upland variables_loading (kg/day/km2) of ammonia and loading of biological oxygen demand in effluent; density of human population within each subbasin calculated from US Bureau of Census 1990 block data.

The extent and width of each riparian cover type was recorded for patches of vegetation observed on 1:40,000 black-and-white air photos of the Big Darby Creek basin. Riparian cover was measured for streams that appear on a 1:100,000 digital line graph of the drainage network.

When a string of patches of the same cover type existed adjacent to the stream the data was reaggregated into a "run". Runs were classified into three types based on the left and right bank cover: (1) forest-facing-forest, or forest-facing-shrub; (2) forest-facing-crop, -grass, or -urban cover, or shrub-facing-shrub; and (3) crop-, grass-, urban-, or shrub-facing-crop, -grass, or -urban cover. The average length and the density of each run type within the subbasin was calculated. Density is defined as the number of runs in a subbasin divided by the total stream length within that basin.

Other upland variables that were not considered in the model included the proportion of basin area in various land use/cover types interpreted from a classified Landsat Thematic Mapper satellite image. The land use classification scheme was coarse and indicated that 98 percent of the total watershed area was in agricultural land use. The resulting lack of variance in land use between the 51 study subbasins indicated that the predictive power of these variables would be limited.

Model Development

In a multiple regression analysis, an exploratory process allowed for the inclusion and/or exclusion of each variable into the regression equation (Equation 1). This model selection process was not automated as is the case for stepwise procedures but was instead iterative in nature. The criteria for model selection was that predictor variables must significantly improve the model and that predictor variables must exhibit a reasonable relationship with the response variable, indicated by the sign of the regression coefficient. The model with the highest multiple r2 and consequently the smallest mean squared error was selected. The resulting model with the best fit is:

IBI = -17.5 + 0.43*MWIDTH2 - 30.2*DENSITY3 + 58.7*DENSITY2 + 0.07*PW2*MWIDTH2 + 0.03*PAREA1*P1LENGTH24 (2)

Residual standard error: 3.9 (45 df)

Multiple r2 = 0.82

Adjusted r2 = 0.80

The definition and significance of each of the predictors are shown in Table 1. The variance inflation factor (VIF) measures the combined effect of dependencies among the predictor variables. If the VIF is greater than 5 or 10 it usually indicates regression coefficients are poorly estimated because of dependency among predictor variables (Montgomery and Peck, 1982; Table 1). Traditionally predictive models are validated by splitting the data set in half, one half to develop the equation and the other half to validate it. Because the number of observations (study subbasins) is small, an alternative method of model validation was used. Four randomly selected subbasins were withheld and the model was built from the n-4 observations. The developed model was then used to predict IBI scores for the four withheld subbasins and this process was repeated 10 times. The resulting best cross-validated model was nearly identical to the model presented above which suggests the model is reasonable and potentially a valid predictor of cases that were not used in it's estimation.

Model Analysis

The relative importance of the predictor variables is evaluated by comparing each predictor's unique contribution to the standardized variance of IBI. As indicated by the squared semi-partial correlations (Table 1), the most important predictor variable is the interaction term PW2*MWIDTH2 which measures the total perimeter of forest patches in the subbasin above a sampling point. Both the extent and width of forested vegetation have a strong positive impact on biotic integrity. The semi-partial correlation measures the correlation between the IBI and an individual predictor variable independent of the remaining four predictors. The interaction term PAREA1*P1LENGTH24 is the proportion of grass vegetation multiplied by the proportion of stream length bordered by grass, indicating that the relationship between grassed area and biotic integrity is affected positively by the presence of grass buffers. Nearly as important is the density of runs, or stretches of stream, bordered by shrub vegetation. There are several reasons why shrub run-density might show a strong positive relationship with biotic integrity. Shrub vegetation is characterized by high biomass production related to higher rates of nutrient assimilation. Other benefits might include some shading of the stream, nutrient inputs to the stream in the form of leaf litter, stabilization of the stream bank, some provision of woody debris, and opportunity for buffering sediment in overland and overbank flow. Less important but significant is the negative relationship between density of runs of either grass, crop, or urban land and biotic integrity. The positive relationship between grass buffer strips and biotic integrity is weakened by this variable.

An analysis of the residuals indicates several trends (Figure 2). Subbasins with IBI scores below 40 tend to be overpredicted by the model. Areas with IBI scores lower than predicted may be impacted by stressors that tend to bypass riparian functions. For example, three subbasins in the northeast quadrant of the watershed, with overpredicted IBI locations, are impacted by cattle access to the stream. Scores in the lower portions of the watershed are consistently underpredicted. This trend is probably related to the heavily forested nature of the lower reaches in comparison to the basin as a whole. Prediction errors in primarily agricultural areas may be related to the types of vegetation and conditions that exist immediately upstream of the sampling point. For instance, an area of heavily forested vegetation immediately upstream of a sampling point in an otherwise modified basin could result in a higher IBI score than predicted.

Conclusions

The success of the spatial model indicates that riparian conditions can modify and buffer the impacts of stressors across the watershed. However, future predictive modeling efforts should focus on stressors and the modifying effects of riparian conditions at several scales, including the area immediately above a sampling location and for whole basin aggregate conditions. Implementation of a spatially-explicit predictive model (White et al., 1992) over a larger geographic area (e.g., the Eastern Cornbelt Plains ecoregion) with the use of similar riparian variables is planned for the next phase of analysis. When sampling locations for biological indicators exist on the same stretch and hierarchical branch of drainage system, a strong possibility exists for the residual regression error ( ) for those locations to be spatially autocorrelated. Further exploration will also employ methods for quantifying the degree of spatial autocorrelation in a sample set and include Moran's I and significance testing of coefficients using randomization methods.

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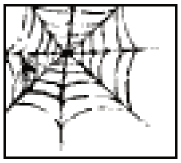

Note: This information is provided for reference purposes only. Although the information provided here was accurate and current when first created, it is now outdated.

Improved Enforcement-Valuable Tool for Watershed Protection-A Local Perspective

Susan V. Alexander
Citizen, Teacher

Throughout the country there seems to be a backlash against the government being involved in the lives of private citizens. Under the guise of protecting American values, elected representatives at all levels of government, from my local county commissioner to my federal congresspersons, seem bent on changing laws and regulations to return rights to ordinary citizens that were never taken away or in danger of being lost in the first place. This is particularly glaring in the realm of natural resource protection.

Using incidents from my local watershed, the middle Sabine River/Toledo Bend Reservoir drainage, as examples, I suggest:

- The viewpoint that anything connected to "big government" is a cancerous evil that must be surgically removed from contact with the public deprives citizens of private property rights, removes individual freedoms, and, in extreme cases like my own, affects private citizens and their families in profoundly negative ways.

- Far from reflecting the will or needs of the majority of Americans, this local, state, and national movement to weaken consumer safety, natural resource conservation, and other public protection laws and their enforcement is contrary to what people really want in their daily lives.

The Sabine Watershed-Its Present Condition and History

The Sabine River drainage basin covers most of east Texas and western Louisiana, the river forming part of the boundary between the two states. Dammed in 1970 to form Toledo Bend Reservoir, the river marks the eastern boundary of Sabine County. Almost half the area is either national forest land or open water and river channel. Timber harvesting and plywood manufacturing are the main sources of income. Poultry production is common in the northern watershed. Unemployment is high, averaging 10% (TEC). Surrounding counties in the larger watershed have similar land use patterns, population, economy, and landscape features.

From about 1860 to 1970 the economy and natural resources of the middle watershed followed a boom or bust cycle. Railroad expansion and mechanized timber cutting and milling favored wholesale harvest of the virgin pine and hardwood timber and the economy boomed. Wildlife such as black bear, deer, turkey, bobcat, wolf, and fox suffered, being virtually eliminated by 1920. Cotton and other cash crops replaced trees until the boll weevil, drought, depression, and soil erosion combined to wipe out most farms. Abandoned farms were left to re-vegetate naturally. By the 1950's the USFS had purchased much of the eroded, denuded land and replanted fast growing pine species. The area was restocked with deer and turkey by the state game and fish agency but unregulated hunting during the 1950's and 1960's and loss of habitat from the second or third timber harvest again eradicated the deer, turkey, and other remaining wildlife populations (TXP&WL, USFS,1988). The current (third or fourth growth) tree crop is mainly low grade pulpwood or chipboard wood.

After the lake was impounded in 1970, Sabine County benefitted greatly from a huge influx of federal and state funds which built campgrounds, access roads, and boat ramps on public land; again replanted clear-cut public and private land; and restocked deer and turkey. Tourists and sportsmen discovered the area adding diversity and money to the local economy. Yet as the county gained more access to the rest of the state, very little changed about county government.

The Current Anti-Government Attitude Has Serious Consequences for the General Public and Individual Citizens

Despite its scenic beauty and extensive natural resources, much of the middle watershed has a long history of few regulations for the health and safety of its citizens and the protection of its environment as well as a spotty record for enforcement in criminal matters.

Lack of Regulations = Chaos

Sabine County currently has no basic building codes for electrical, structural, or plumbing work, no septic or sewerage ordinances, no zoning, no animal ordinances or pound, no local health inspector, no juvenile detention center, no approved landfill, and no county road and bridge construction and maintenance standards. Inspections by most state agencies are limited to the two small package waste water treatment plants and minimal evaluation of local restaurants. State inspection of septic tanks, new or existing, has not been documented.

As a result many homes lack basic sanitary services. Cess pools, waste ponds, and direct discharge of human waste to land and water are routine. The county is under a rabies quarantine. Many private wells are inadequately cased. Old dug wells are still used in a few instances. Fire losses are not uncommon due to inadequate or antiquated wiring and heating systems. We lamely joke about the front page newspaper story about the wreck of the week, but serious accidents are common on our winding, poorly constructed and maintained county roads. It is evident from the lack of local ordinances in my watershed, that the local citizenry and local government place a low priority on laws and regulations, even when those very laws protect basic human health. Part of this lack of local governmental service stems from ignorance but part stems from self-deceptive thinking that places a higher value on a person's right to have a cess pool than on the health of his or her family and the community.

Some People Resent Enforcement of Any Law, Particularly Resource Protection Laws

State police officers in Sabine County enforce highway safety regulations and parks and wildlife codes. Texas wildlife laws are significantly different from the state's other natural resource laws (water, air, and soil). Game wardens, employed by the Texas Parks and Wildlife Department (TXP&WL) are state certified peace officers who enforce criminal and civil wildlife and outdoor safety laws on both public and private property. Their presence is often resented as an invasion of privacy. Two viewpoints, both equally damaging to wildlife, are common. Some people consider wildlife as personal property, like the soil or vegetation on their land, thus giving landowners the right to use the resource they please. Others view wildlife as public property, free for the taking by whoever can get the most, first. In both cases, this often means harvesting as many deer, squirrel, duck, fish, etc. as possible using any means available.

Resentment over the enforcement of game and fish regulations may seem to be out of proportion with the penalties for a violation since most are misdemeanors (similar to speeding tickets). For our family, this resentment took an extreme, violent, and irrational form.

Although most counties in Texas had long ago passed local ordinances that outlawed hunting deer with dogs, in the Sabine River watershed a state law with state enforcement seemed the only way to eliminate this destructive type of hunting. One was enacted in 1990. Not surprisingly, in Sabine County, no corresponding local laws have been added to enhance the state ban on hunting deer with dogs and no local support services exist for dealing with evidence or confiscated property associated with these crimes.

We were stationed here in 1991, the year enforcement of this locally unpopular law began. As time passed, my husband, the game warden, became more adept at catching violators and tension escalated. Threats, ripped tires, annoying phone calls, and other forms of intimidation increased. On the night of December 4th our almost completed new home was burnt to the ground by some poachers and their friends who had been arrested earlier that day for illegal hunting (misdemeanor) and tampering (a felony) with state evidence (the dead fawn).

Local law enforcement officials were slow to act. No arrests or investigations were made the night of the fire. Three of the arsonists felt so immune to prosecution that they openly drove around town bragging to friends about the crime later that evening. With pressure from TXP&WL, the sheriff "invited" the Texas Rangers and State Fire Marshall to investigate. Three days later 3 men were questioned, arrested, then released on bond. A grand jury met a few months later and handed down a first degree felony charge.

An Anti-Government Attitude Creates a Climate That Encourages Terrorism and Intimidation-Certainly Not American Family Values

The first trial for the arsonists ended in a mistrial. Although the evidence was overwhelming, the defense attorney swayed the jury foreman by arguing throughout the trial along the anti-government, anti-environmental, pro-individual freedom line. During closing arguments the attorney stated, "This is not really a case about burning an unoccupied building, it is about a plot by the government, namely Texas Parks and Wildlife, to control, overrun, and deprive the citizens of Sabine County of their rights." (State of Texas vs. Lennis Bo Rice, 5th Circuit Court, May 24, 1995) He was not just arguing to the jury, the courtroom was full of sympathizers for the defendant. This argument was an echo of a peculiar set of values that labels anything to do with government as an infringement of individual freedom.

I believe that some important attitude factors contributed to this tragedy. The criminals and their friends (who have not been charged or indited) clearly felt they could get away with a blatant crime. The reasons are probably complex, but it was clear that these criminals felt terrorism, retaliation, and lawlessness were permissible in Sabine County simply because many people in our area think the dog hunting laws are unfair. Some of our locally elected officials have perhaps unwittingly contributed to this attitude through their choice of companions, private opinions, and job performance, but they reflect the attitude we see from our nationally elected officials. This irresponsible viewpoint sends a strong and dangerous signal that is short on individual duty and public trust and long on personal gain. I believe this attitude plays right into the hands of criminals and terrorists_individual and corporate ones.

The point is that we need good laws and strong enforcement for protecting everyone's right to clean water, air, soil, wildlife, and health because there are bad people in the world. There are the criminals who justified burning our home because they felt the government was depriving them of their right to poach just as there are people who currently are justifying actions which erode the health and welfare of many Americans over the long term by allowing unregulated pollution and exploitation of our natural resources for the short term financial gains of a few. Perhaps the second example is not as obvious as arson, but I suggest that it is just as serious. It is time that Congress, state legislatures, and local governments focus on the needs and rights of the majority, for losing sight of the public good has serious consequences to individuals_real people like my family.

Lack of A Government that Provides Support, Service and Protection is Not What People Really Want

The pendulum of public policy swinging away in capitols across America may not really reflect the will of the majority, if the majority will just slow down a minute and really think about what it wants. The old adage "there are no atheists in foxholes" might have some type of corollary applicable to watershed protection. I have observed that what people tacitly agree with, or even actively say they want, may not be borne out in their daily actions when the truth often arises.

People want "someone" in government to protect their rights and property

As one of the few state employees in the county, we get quite a few non-wildlife calls for help (calls are routed to our home rather than the sheriff's office). These may explain more concretely the discrepancy between what people say they want, and what they show they want.

- My neighbor was burning trash and it caught my shed on fire, come arrest him.
- My neighbor's dogs/pigs are all the time running across my land, come get them and tell him to keep his animals up.
- My pond is all green and it stinks like pig manure. Write my neighbor and his pigs a ticket and get him to clean up my pond.
- The pharmacist is dumping chemicals behind his shop, arrest him.
- The people up the road keep fishing in my pond without my say so, chase them off, tell them you will take them to jail if you catch them again.
- My neighbor is throwing old fisheads in my bar ditch, go make him clean up the mess.

The problem is not with the complaints, its with the solution. Almost all require action on the part of the landowner, such as telling trespassers to leave, asking a neighbor to stop objectional behavior or actions, or actually signing a complaint/filing charges against someone. The people doing the complaining don't want to do something themselves, they want someone to do their dirty work for them. This is human nature. Few people want to confront neighbors, some from embarrassment and some from fear of retaliation. People say they want to, and should be able to do as they please on their own property, but if something or someone is bothering/hurting them by their actions, they want someone else (the government) to take care of it. A lack of support or service is not what people demonstrate they want from their government in times of personal need.

Justifications for Dissolving/Weakening Laws and Enforcement are Often Not Based on Reality

Attempts to justify dissolving regulatory powers of state and federal officials often use a number of arguments that do not bear close examination. Peer regulation and self-policing or oversight programs are touted as one example of effective replacements for state and federal enforcement. Yet if we but look at how people act, it is doubtful that these type of programs work well. Certainly self or peer regulation is better than no regulation, but it is unrealistic to expect most neighbors (individual or corporate) to rat on each other, particularly when there are few laws or penalties to backup the complainant. Let's be realistic, how can we expect industry to police itself if we can't even ask our own neighbors to return a lawnmower or stop dumping fisheads?

Other arguments for decentralizing government suggest that local governments are best suited to make decisions_in general a good argument, but there are some exceptions. In some instances local people will not do what needs to be done to protect the majority. In my county the "ain't no one died yet" philosophy keeps us from septic tank ordinances, or the taxpayer expense of a sanitarian. In other instances, local people don't have the resources, financial or otherwise, to deal with problems that go beyond local jurisdiction. Additionally, local people can, but may not, have or choose to get access to the latest data or information (it takes time, effort, and some degree of technical knowledge) needed to make informed decisions.

One particularly misconceived expectation is that local officials are more accountable than state or federal government people. Local officials are only accountable if someone checks, and even then, in Texas at least, you can't get rid of them until the next election. To illustrate: before state and federally mandated redistricting we had four locally elected Justices of the Peace that set fines/punishment for all classes of misdemeanors. Often the fines were minuscule, $25.00 for a poached deer. Worse, sometimes the fines were not actually collected, sometimes due to poor bookkeeping and sometimes because the locally elected constables responsible for their collection just didn't do so. Unless it is blatantly criminal, local people don't even notice what goes on in local government; they simply do not have the time, knowledge, or energy to check on their government themselves and state and national consumer safety and environmental protection watchdog groups cannot track millions of tiny, local actions nor intervene in thousands of local cases.

Summary

Weakening natural resource laws, regulations, and their enforcement sends the wrong message to the public, particularly to that element of society looking for a chance to exploit public resources and individuals under the guise of personal freedom. This is not freedom_it is anarchy_it encourages actions that hurt regular, law abiding citizens. People show through their daily actions that they want a government that protects them and their property. It is the job of our local, state, and national leaders to provide people with those services and protect those rights, regardless of the pressure applied by either unscrupulous or well-meaning individuals or groups.

Development of the Use Restoration Waters Program

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Need

The term "nonsupporting designated uses" refers to waters that the NC Division of Environmental Management (DEM) has rated as poor based on biological, physical or chemical information such that the uses are no longer attainable. "Partially supporting designated uses" refers to waters that are impaired but still partially support some classified uses. Widespread examples of partially supporting waters are SA waters (the highest classification of salt waters in North Carolina) in which shellfishing beds are closed due to elevated fecal coliform concentrations. It is difficult to restore these waters because of the great number of possible sources of fecal coliform discharge.

In an effort to address documented water quality problems, DEM has been developing a Use Restoration Waters (URW) Program. The URW program will allow the state to cooperate with local interests in developing a mix of mandatory and voluntary measures to restore waters that are not supporting their uses.

Application of the URW Program

The URW Program will apply to polluted surface waters where the following conditions apply:

- Biological, physical and/or chemical data indicate the specific sources of pollution.
- A use attainment study indicates that the sources of pollution are not transitory.
- It is possible to control the sources of pollution by implementing appropriate management strategies under the existing authority of the North Carolina Environmental Management Commission (EMC).

Based on current water quality data, there are approximately 4,300 miles of freshwater streams (or about 1.4 percent of total miles) and about 40,000 saltwater acres (or about 2 percent of total saltwater acres) that would be potential candidates for URW consideration.

Prioritizing Waters

The Division will place waters that pose a serious health threat, such as toxicity, as a priority over less serious pollution problems. Secondary priorities will be as follows:

- Existing Data Set: DEM will prioritize waters that have extensive existing data sets, including a USGS gauging station, ambient monitoring records, soils and land use maps.
- Public Interest: DEM will prioritize waters that have the support of the public and local agencies for restoration efforts.

Possible Mandatory Components of the URW Program

The restoration strategies developed under the URW Program will be site-specific to the watershed of the nonsupporting or impaired water body. The stakeholders will coordinate each URW strategy with other agencies' programs to create a holistic approach to address the array of pollution problems in the watershed. The components described below may be implemented as mandatory measures.

Identifying Pollution Sources

To initially target restoration efforts, consideration will be given to water quality ratings based on DEM monitoring within small watersheds (2,000 to 20,000 hectares). These watersheds have been delineated by the Natural Resources Conservation Service (NRCS) and represent the smallest watershed mapping unit available statewide in digital form. A geographic information system (GIS) will then be utilized in conjunction with an appropriate watershed scale water quality model and other data sets to further define the specific sources of use impairment. Potential data sources include:

- USGS gauging station data
- Ambient chemical monitoring records
- Benthic macroinvertebrate and fish tissue monitoring
- Digital soils layers
- Landsat Thematic Mapper satellite imagery of existing land uses
- Aerial photography
- Digital land parcel ownership records
- 1:24,000 scale digital orthophotos
- Digital elevation model
- 1:24,000 digital hydrography
- Location of existing Best Management Practices (BMPs)
- Soil and Water Conservation District records

The data may be compiled through cooperation and partnerships among government agencies, non-profit groups, businesses and industry. The limit of GIS is that site-specific analyses of pollution sources and reduction strategies cannot be discerned at the scales of most digital data. At the site-specific level, the URW program will depend on the local knowledge of community resource agencies and landowners.

Targeting BMPs

BMPs have been the primary method of pollution control for the past 20 years. Recently, researchers and engineers have given more attention to targeting BMPs that are appropriate and cost-effective for a particular site. The type of BMP will be dependent on the pollutant to be controlled and geographic considerations. For example, mandatory agricultural BMPs may include individual permits for animal operations, nutrient management, controlled drainage, forested riparian buffers. Some mandatory urban BMPs may include riparian buffers, wet detention ponds, illicit connection programs, constructed wetlands, infiltration systems,and bioretention areas. In all settings, stakeholders will target BMPs for the particular site that they intend to serve.

Point Source Control (if necessary)

Depending on the type of pollutant causing the water quality degradation, DEM will consider controls for point sources. This may require additional or more stringent effluent limitations. It may be necessary for existing and expanding wastewater discharges to be evaluated on a case-by-case basis. The stakeholders could require new industrial dischargers to demonstrate that discharge is the only environmentally and economically feasible option and to meet specific limits for certain pollutants.

In addition, a trading option may be considered where dischargers may offset their additional pollution loads by funding nonpoint source control programs approved by DEM. These programs include agricultural cost share programs, wetland restoration, urban cost share programs, etc.

Riparian Buffers

Riparian buffers may be another requirement under the URW program. Riparian buffer systems are streamside ecosystems that are managed for the protection of water quality. By maintaining the stream environment, buffers control nonpoint source pollution. They remove or buffer the effects of nutrients, sediment, organic matter, pesticides and other pollutants prior to entry into surface waters and groundwater

Table 1. Possible Mandatory Components of the URW Program

Component of Program	Description
Identifying the Problem	• Gather existing data set. • Create/utilize a GIS. • Create a watershed scale model. • Test model with data set. • Specifically identify primary pollution sources.
Targeting BMPs	• Specify SMPs that are tailored to the site. • Obtain funding from appropriate agencies. • Use model to track BMP effectiveness.
Point Source Controls (if necessary)	• Evaluate existing and expanding dischargers case-by-case. • Set limits for new dichargers. • Consider the use of offset fees that would fund BMPs and/or stream restoration projects.

Riparian buffers	• Determine the potential effectiveness of buffers on a site-specific basis. • Specify design criteria for riparian buffers. • Obtain funding from appropriate agencies.

recharge areas. For optimal performance, riparian buffer systems must be designed and maintained to maximize sheet flow and infiltration and impede concentrated flow.

If riparian buffers are required, DEM will coordinate funding from the appropriate agencies. Some possible sources of funding include: Conservation Easements, NC Division of Water Resources Stream Repair Funding, NC Agricultural Cost Share Program (ACSP), the Natural Resource Conservation Service, Federal Agricultural Conservation Program (ACP), and the Federal Scenic and Wild Rivers Program.

Possible Voluntary Components of the URW Program

A team of stakeholders will coordinate voluntary efforts to complement the mandatory components of the URW program. Some of these voluntary efforts may include the following.

Creating a Team of Stakeholders

Each site-specific strategy would be developed in coordination with a team of stakeholders who would include citizens, environmental groups, industrial interests, and local, state, and federal agencies. Voluntary aspects of the URW program may include incentives for the stakeholders. For example, the state may offer low-interest loans and technical guidance to a community if the community contributes toward costs and organizes the project with citizen participation.

Ecosystem Restoration

Although reducing nonpoint and point sources of pollution will be the primary emphasis of the URW program, the stakeholders should also consider the structural and functional integrity of the entire aquatic

Table 2. Possible Voluntary Components of the URW Program

Component of Program	**Description**
Creating a Team of Stakeholders	• Invite citizens, environmental groups, industrial interest, and local, state, and federal agencies to participate. • Look for incentives for stakeholders to participate.

ecosystem. When a stream ecosystem, including the adjoining floodplain and tributaries, has been radically disturbed, recovery may be an extremely prolonged process. In such cases, reducing the pollutant input only represents a partial solution.

Ecosystem Restoration	• Determine if riparian area restoration is necessary. • Coordinate ecosystem restoration efforts with the Wetland Restoration Program and other relevant agencies.
Public Education	• Obtain information about existing environmental education programs that pertain to the URW Program. • Determine which audiences need additional education about the URW. • If possible, tailor existing programs to URW needs. • If necessary, obtaian funding from appropriate agencies for educational programs.
Coordinating Existing Programs	• Develop cooperative relationships relevant agencies. • Consolidate and target overlapping efforts.

Several aquatic ecosystem restoration initiatives in North Carolina currently tend to operate independently without prioritizing and consolidating their effort; these efforts include the NRCS Wetland Reserve Program, state funding for stream restoration, restoration efforts of environmental organizations, and mitigation requirements. To coordinate these initiatives, the state is developing a Wetland Restoration Program that would provide statewide leadership in targeting and consolidating wetland and riparian area restoration projects. The Wetland Restoration Program and the URW program could combine site-specific pollutant reduction strategies with targeted ecosystem restoration efforts and greatly increase the ecological effectiveness of both programs.

Public Education

Public education programs prevent environmental problems before they occur rather than treating them later. An effective URW strategy must involve a strong educational component. Regulation and technical assistance, without education, are not sufficient to influence the daily decision making by each individual living in a watershed. Public education programs are often implemented through cooperation and partnerships among government agencies, non-profit groups, businesses, and industry. These will be coordinated and strengthened under the URW program.

An important component of the program will be to inventory environmental education materials. Materials, such as pamphlets, workshops, exhibits, outings, and soil testing material, could be components of an existing environmental educational program. Stakeholders should look for gaps in the distribution and publicity of existing programs. If necessary, the stakeholders should produce and distribute a "user friendly" guide to pollution prevention to citizens, businesses, and industries. The stakeholders should search for opportunities for state, federal and local government agencies to support environmental education in their URW watershed.

Coordination of Existing Programs

Developing interagency cooperation in targeting existing incentives and funding for agricultural and urban best management practices will be another key component of the URW program. Cost-share practices providing resources for implementation of various BMPs are administered somewhat independently by multiple agencies without rigorous prioritization for cost-effectiveness. The URW program will attempt to develop cooperative relationships among these agencies so that overlapping efforts can be consolidated and targeted to maximize restoration of designated water body uses.

Conclusion

The URW program will be a coordinated and holistic effort to address documented water quality problems. In order to be effective, the URW program will include a mix of mandatory and voluntary programs. The mandatory programs will be coordinated on a site-specific basis by DEM. The voluntary programs will be coordinated by a group of stakeholders who have an interest in the impaired water body and associated watershed. In addition, the URW program will attempt to develop cooperative relationships among these agencies so that overlapping efforts can be consolidated and targeted to restore designated water body uses.

Optimal Trading Between Point and Nonpoint Sources of Phosphorus in the Chatfield Basin, Colorado

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Introduction

Nutrients continue to be the most often-reported pollutant causing use impairments in lakes and reservoirs throughout the nation (EPA, 1995). The source of these nutrients in many watersheds tends to be a combination of point sources (PS's) and nonpoint sources (NPS's) thus prompting the need to look at ways of managing these sources in a balanced fashion. In addition, the US Environmental Protection Agency (EPA) has recently published a policy that acknowledges the benefits of pollutant trading between and among the various sources within a watershed as a means of reducing costs in the course of meeting Clean Water Act objectives (EPA, 1996). This paper examines PS/NPS trading from an economic efficiency perspective in the Chatfield Basin of Colorado. The trading issue considered is to find the optimum PS/NPS tradeoff of total phosphorus such that total costs are minimized while still achieving an acceptable overall reduction level in the watershed. It was determined that a relatively high degree of PS treatment (1.0 to 0.5 mg/l effluent total phosphorus) should be attained before structural NPS controls become cost-effective. It is believed that this finding perhaps more importantly demonstrates the economic costs of failing to use source controls, as opposed to structural controls, to prevent NPS pollution in the first place.

Background

Chatfield Reservoir is a US Army Corps of Engineers owned and operated facility located on the South Platte River just southwest of Denver, Colorado. The Reservoir was completed in 1976 for purposes of flood protection for the metropolitan Denver area following the disastrous South Platte flood of 1965. Since that time, Chatfield Reservoir, which is now a State Park, has become increasingly popular as a recreational facility and concern over possible decreases in water quality due to upstream nutrient loadings has arisen. The in-Reservoir total phosphorus standard has been set at 0.027 mg/l to be protective of a seasonal chlorophyll-a goal of 0.017 mg/l. The 0.027 mg/l phosphorus standard corresponds to a total maximum annual load (TMAL) of 59,000 pounds. (The standard and the corresponding TMAL are highly uncertain, however, and additional in-Reservoir water quality modeling is planned to better estimate the relationship between the standard and the chlorophyll-a goal.)

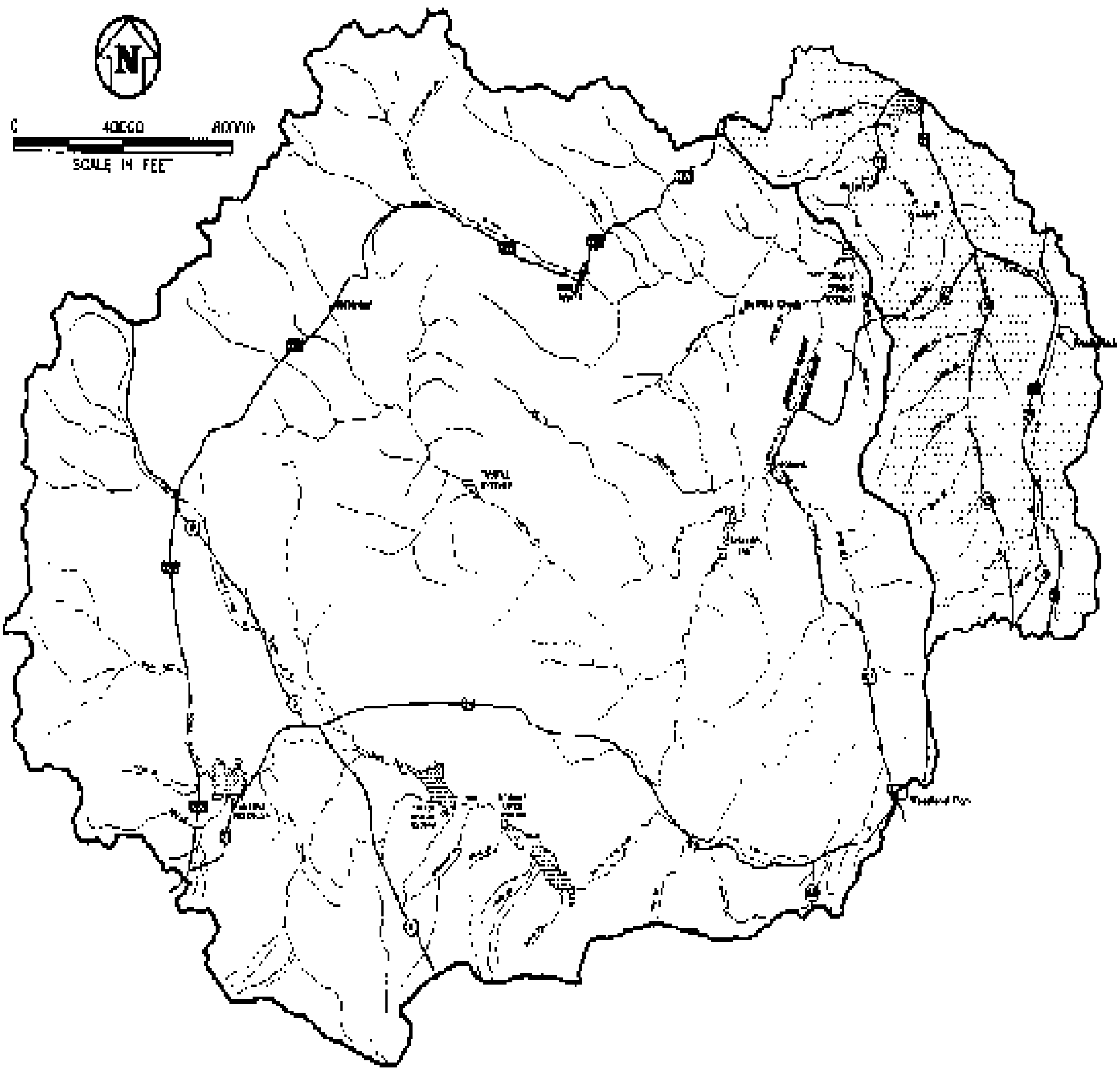

Figure 1.Cahtfield Basin and Plum Creek Study Area.

The upstream watershed, called here the "Chatfield Basin" and shown in Figure 1, encompasses a total area of approximately 3,000 square miles and covers portions of six counties. It includes the headwaters of the South Platte River and extends westward to the continental divide and south almost to Colorado Springs. The South Platte River portion of the basin is largely undeveloped and includes portions of the Pike National Forest and the Mount Evans Wilderness area. Some small urban areas and agricultural uses are also present. The eastern portion of the Chatfield Basin is comprised of the Plum Creek watershed, approximately 300 square miles in area. The Plum Creek watershed, although predominantly rural, is much more intensively developed than the South Platte River drainage and is believed to contribute the majority of the nutrient loads to the Reservoir. The estimated 1995 total annual raw (no PS or NPS removal) load to the Reservoir from the entire Basin under 1-in-10 year high runoff conditions is approximately 207,000 pounds. Thus, under the current TMAL estimate, some 148,000 pounds (207,000 - 59,000) need to be removed to maintain the total phosphorus standard.

In 1992, a watershed management study was performed by Woodward-Clyde Consultants (WCC, 1992) of Denver for the Chatfield Basin Authority, the intergovernmental management agency for the Chatfield Basin. The WCC study determined that the source of annual phosphorus loading was overwhelmingly from nonpoint origins and that control of these NPS's would be needed to meet the in-Reservoir phosphorus standard. Despite the state regulation requiring 0.2 mg/l effluent phosphorus for the Plum Creek publicly owned treatment works (POTWs), only one discharger had managed to achieve compliance at the time of the WCC study.

Understandably, following the WCC determination that PS's of phosphorus are dwarfed by the remaining nonpoint component, the remaining POTWs were reluctant to proceed further with meeting the regulation without reassurance that additional PS removal was indeed cost-effective. The Colorado Water Quality Control Commission (Co WQCC) agreed and relaxed effluent limits to 1.0 mg/l, a level that could be met without extraordinary capital construction, until such time as the appropriate PS/NPS phosphorus load allocation (PS/NPS LA) could be better determined. This study (WCC, 1994) examined that issue and was funded by EPA.

Scope and Objectives

This study examined the PS/NPS LA issue for those portions of the Chatfield Basin that discharge directly into Chatfield Reservoir, i.e. the Plum Creek subbasin, the South Platte subbasin downstream of Strontia Springs Reservoir, and several smaller subbasins contiguous to Chatfield Reservoir ("Plum Creek Study Area" on Figure 1). These subbasins were identified in the WCC NPS Plan as high priority subbasins for examination of NPS control measures. Those portions of the Chatfield Basin not considered in this study are generally much less developed than the contiguous subbasins. In addition, they are also tributary to one or more other reservoirs. Thus, at least from the perspective of protecting water quality in Chatfield Reservoir, these upstream reservoirs can effectively be thought of as existing NPS controls. That is not to say that NPS controls do not need to be considered in those subbasins; however, any such controls would serve largely to protect water quality in the upstream reservoirs, with only secondary benefits to Chatfield.

The overall objective of the study, from the local perspective, was to determine the optimal (minimum cost) total phosphorus PS/NPS LA in the Plum Creek Study Area. Specifically, the optimal PS/NPS LA was determined as a function of total phosphorus load required to be removed annually. Thus, for a given annual load that should be removed to protect water quality, the cost-effective tradeoff between point and nonpoint treatment can be determined from this function. From EPA's perspective, an additional study objective was the development of a methodology to determine cost-effective PS/NPS trading schemes, not only in the Chatfield Basin but potentially applicable in other watersheds as well. Thus, the methodology presented in this paper, while described specifically for the Chatfield application, is transferable in principle to other watersheds.

Treatment Costs

Twenty year present worth treatment cost functions were developed for both PS's and NPS's. PS costs included only the additional costs (capital and operating) to remove phosphorus by chemical means, and were based on data from EPA (1987) and Murphy and Associates (1983). NPS treatment costs assumed that stormwater detention basins were the preferred best management practice (BMP) type, and were based on data provided by Schueler (1987).

Optimal Point Source WLA

An optimization analysis was first performed to develop the minimum cost wasteload allocation function for PS's only. This optimization determined, for any given total annual load removed by PS's, the least cost means of attaining this removal among the six PS dischargers. The marginal cost principle was the basis of the optimization such that a given annual load removed was allocated among the dischargers in accordance with their marginal treatment costs. The result of this analysis was a function yielding minimum present worth PS treatment cost as a function of total annual phosphorus load removed among the dischargers (Figure 2).

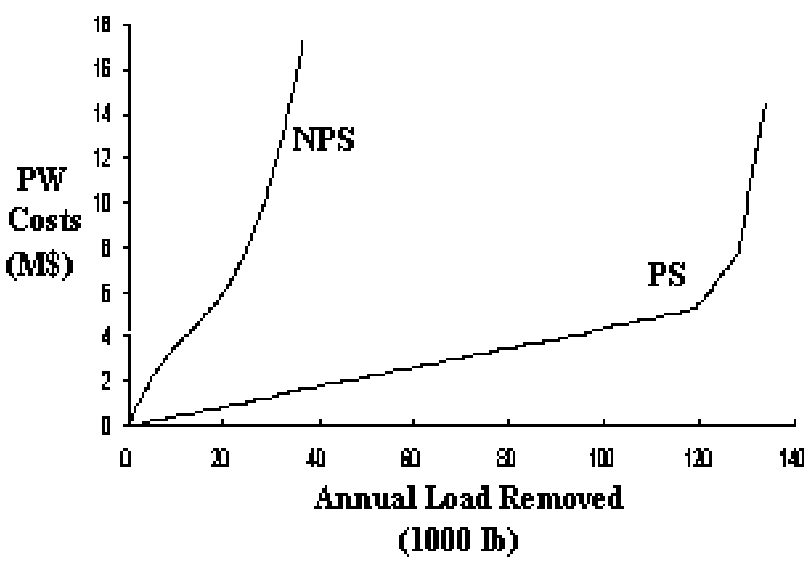

Figure 2. PS and NPs Minimum Cost Functions.

Optimal Nonpoint Source LA

Similarly, a function relating minimum treatment costs for NPS's only as a function of total annual NPS load removed was developed. Given that some 40 discrete (non-contiguous) urbanized areas exist within the Plum Creek Study Area, this optimization problem was essentially whether to build 40 individual detention basins, 1 regional detention basin, or some number in between. This optimization problem was originally formulated as a mixed-integer linear program, but proved prohibitively time-consuming to solve. Instead, a more conventional approach was taken wherein a limited number of alternatives were individually costed and the minimum selected. A single, regional detention basin was determined to be the optimal configuration. (The mixed-integer linear programming model, "BMPOPT", has since been improved and is described elsewhere in these Proceedings.)

Under the assumption that NPS controls should be protective of the Reservoir during 90 percent of years, a time series of runoff events representing the 1-in-10-year hydrology was developed. Phosphorus loads were also developed for these events, and the design time series was then routed through the regional detention basin for each of a variety of alternative basin volumes. For each alternative basin volume, the routed time series of runoff and phosphorus loads resulted in a total annual load removed by the detention basin. The result of the analysis thus yielded minimum NPS treatment costs as a function of total annual load removed among NPS's only (Figure 2).

Perhaps surprisingly, the optimal NPS cost function in Figure 2 reveals much higher costs for NPS phosphorus control than PS controls. This cost difference is attributable to at least the following factors: (1) the use of structural BMPs, (2) the choice of capturing runoff from the 1-in-10 runoff year, instead of a more typical year, and (3) the relative ineffectiveness of detention basin phosphorus removal (assumed at 45 percent). It is not known to what extent these relative cost differences might also apply in other watersheds.

Optimal PS/NPS LA

The optimal PS and NPS load allocation functions are shown together in Figure 2. Each represents the minimum cost of removing load from that source only. The PS/NPS LA question is then: What is the function representing optimal allocation between PS's and NPS's?

The optimal PS/NPS LA function was developed by solving a series of nonlinear programming models. The decision variables were: X1 = annual load removed by PS's and X2 = annual load removed by NPS's (during 90th percentile year). The objective function was: MIN [Cost(X1) + Cost(X2)] where Cost(X1) is the minimum present worth cost function for PS's, discussed previously, and Cost(X2) is the minimum present worth cost function for NPS's, also discussed previously. Constraints on the optimization model were that X1 plus X2 equal the total annual load removed and, further, that X1 and X2 must be less than or equal to technological upper limits.

The nonlinear programming model model was solved for a variety of total annual loads removed. The resulting minimum cost PS/NPS LA function is shown in Figure 3 and the specific allocation between PS and NPS in Figure 4. Interestingly, but perhaps not surprisingly given the high NPS costs, PS's are used exclusively to remove phosphorus up to an annual removal of approximately 128,000 pounds. Beyond this, it becomes economical to begin removing some of the additional load by detention basins. Thus, of the currently estimated 148,000 pound annual load to be removed, the first 128,000 pounds would most economically be achieved by the PS's with the remaining 20,000 pounds to be removed by a regional detention basin. The 128,000 pound PS WLA corresponds to a uniform effluent concentration among all 6 dischargers of approximately 0.5 mg/l. (Given the study assumptions and uncertainties, this concentration is not considered to be significantly different than the 1.0 mg/l effluent concentration tentatively established by the Co WQCC.)

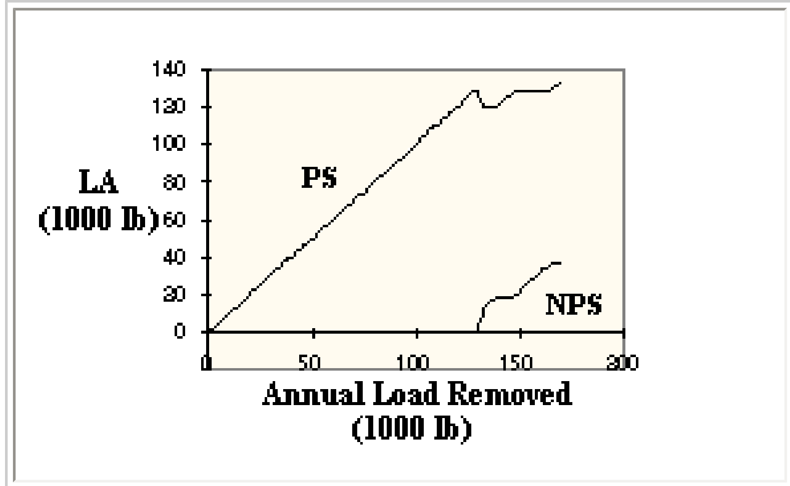

Figure 3. Minimum Cost Function

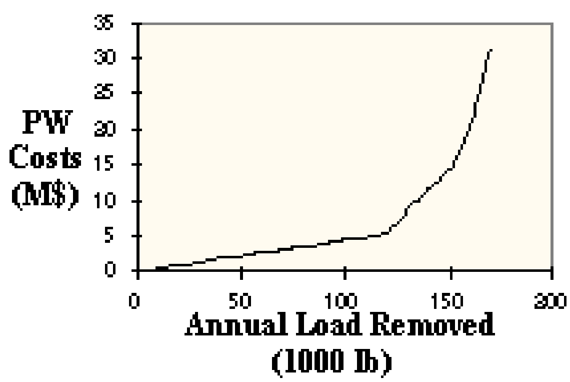

Figure 4. Optimum Load Allocation Schedule.

Conclusions

The immediate conclusion from this study is that there is indeed an economically optimal balance between PS and NPS controls, which can be determined as a function of load to be removed using methodologies similar to those discussed here. PS/NPS trading decisions made without knowledge of this cost-effective balance can result in significant cost inefficiencies.

Beyond this obvious result, a secondary conclusion emerges. There seems to be a prevailing belief in the watershed management community currently that removal of NPS pollutants constitutes almost a panacea for water quality problems, because NPS removal is regarded as generally less expensive than PS controls. However, the results of this study suggest, at least for the Chatfield Basin, that structural NPS control is not nearly as cost-effective as might have been previously believed _a relatively high level of PS phosphorus removal is economically efficient before structural NPS controls are appropriate.

It is not known to what extent this secondary conclusion might apply in other watersheds. If it is applicable beyond the Chatfield Basin, the authors believe that the real value of this study lies not so much in guiding phosphorus allocation between PS's and structural NPS's, but rather in quantifying the economic costs of failing to prevent NPS pollution in the first place. If source controls (e.g., erosion control, agricultural BMPs) are not in-place and effective at preventing NPS pollution, structural controls, such as the detention basins used in this study, are then necessary. As demonstrated here, this after-the-fact treatment is very expensive.

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Opportunities and Obstacles in Watershed-Based Regulatory Programs: The Stormwater Initiative in Massachusetts

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Introduction

The merits of using the watershed as the basic hydrologic unit are recognized. Relying solely on the watershed approach for regulatory programs is more problematic for several reasons. Existing regulations based on permitting by resource agencies largely ignore the boundaries of the resource that they are designed to protect. State agencies have historically instituted regulatory approaches which create a "level playing field" for permittees statewide, rather than tailor the level of protection to unique circumstances of each watershed. Local government may play a significant role in environmental permitting, but municipal and watershed boundaries are not aligned. Sources of water quality impacts may not be susceptible to traditional permitting because they are predominantly nonpoint source or stormwater point sources. Local governments sharing a watershed may not share legal mechanisms to control or influence activities within the watershed.

The Massachusetts Department of Environmental Protection, working in cooperation with the Office of Coastal Zone Management, proposes to combine watershed and nonwatershed-based approaches in developing a comprehensive program to address the impacts of stormwater. Massachusetts has extensive but overlapping authority to regulate stormwater discharges, but has lacked a coordinated and consistently implemented program. The stormwater initiative envisions combining technical guidance for review of new development primarily at the local level with a watershed-based approach for state assessment and remediation of water quality problems from existing stormwater discharges. An advisory committee of stakeholders was convened to discuss performance standards and implementation, which will result in a blend of traditional permitting and the watershed approach.

The Watershed Approach in Massachusetts

The Massachusetts Watershed Initiative envisions a partnership of government, environmental, and business groups within each watershed to improve water quality. Local in focus, the initiative emphasizes grass-roots efforts to prevent or remediate pollution at its sources. A methodology to support these efforts includes outreach and technical assistance, assessment, planning, and plan implementation including permitting and enforcement. Some funding for improved watershed management is anticipated from the state. State resource agency activities have been reoriented to implement the watershed approach. Teams of agency staff are assigned to each basin and are responsible for supporting watershed management within each watershed on a rotating schedule from outreach to assessment, through planning to permitting. Activities that were performed ad hoc and in isolation, such as NPDES/MA surface water discharge permits and regulation of groundwater withdrawals, will be performed at the same time so that relationships within and between water resources are addressed. The five-year rotating schedule for agency staff activities identifies a single focus each year to be performed in each basins: reconnaissance, information development, assessment, solutions (including NPDES permit issuance), and evaluation.

Regulations covering stormwater discharges predate the watershed approach. Under the state Clean Waters Act, MGL c. 21 ss. 23-56, a permit is required for a conveyance for stormwater runoff that is "contaminated" by contact with raw materials, toxic substances, or oil and grease. "Contaminated" has no regulatory definition. Stormwater may also be designated for a permit on a case-by-case basis as a significant contributor of pollution to state waters. Due to limited administrative resources, Massachusetts has rarely issued permits for stormwater discharges.

The Wetlands Protection Act in Massachusetts

While the Watershed Initiative is relatively new, Massachusetts also boasts the oldest and perhaps the most successful wetlands protection program in the nation. Since the 1960s, the comprehensive statute has both directly and indirectly provided protection of water resources. Administration is shared by local and state government. The regulations apply statewide in all watersheds, and the permit process is ad hoc as developments are proposed, in contrast to the watershed context and schedule for NPDES/MA permits.

Under the Wetlands Protection Act, MGL c.131 s.40, local conservation commissions and the Department have responsibility for ensuring wetlands protection through the issuance of permits for activities in floodplains and in or near wetlands and waterbodies. The public interests served by the act are public and private water supplies, groundwater supply, prevention of pollution, flood control, protection of land containing shellfish, protection of fisheries, storm damage prevention, and protection of wildlife habitat. Proposed work in a resource area, and within a 100 foot buffer zone if it will alter any resource area, requires a permit. Resource areas include freshwater and coastal wetlands, banks, beaches, and dunes bordering on estuaries, streams, ponds, lakes, or the ocean; land under any of these water bodies; and land subject to tidal action, coastal storm flowage, or flooding. Resource areas are protected by specific regulatory performance standards that must be met to obtain project approval (e.g., except for limited circumstances, no more than 5000 sq. ft. of bordering vegetated freshwater wetlands may be altered and any filled area must be replicated).

Although stormwater discharges clearly implicate most of the public interests that the Wetlands Protection Act is designed to safeguard, the regulations have no specific provisions for stormwater. However, the authority to regulate stormwater is implicit in the regulations. For example, routing of stormwater can trigger jurisdiction by altering drainage characteristics, sedimentation patterns, flow patterns, flood detention areas, water temperature, and affect the physical, chemical, or biological characteristics of the receiving water. In addition, the performance standards often indirectly require control of stormwater discharges, such as the prohibition on the impairment of surface water quality for work on banks or land under water. In the absence of a NPDES permit, local conservation commissions and the Department of Environmental Protection are instructed to impose conditions on the quality and quantity of discharges from either closed or open channel point sources to protect the interests of the act provided the point source is within a resource area or the buffer zone.

In addition Massachusetts' new 401 certification regulations for Corps of Engineers' 404 permits for discharge of dredge and fill material contain explicit provisions for stormwater management. No fill in natural wetlands is allowed for pollutant attenuation; fill in wetlands for any stormwater management purpose or any direct stormwater discharges to outstanding resource waters (in Massachusetts, surface water supply reservoirs and tributaries, certified vernal parts, and any other designated areas) is prohibited. This program is implemented by the state on an ad hoc basis as development is proposed rather than through the watershed process.

The Massachusetts Stormwater Initiative

Although authority to require stormwater management in Massachusetts is evident under the Wetlands Protection Act, the state Clean Waters Act, and the new 401 certification regulations, stormwater discharges are causing water quality problems. While industrial and municipal treatment facilities have greatly improved the quality of their discharges, most stormwater continues to flow untreated into wetlands, lakes, ponds, streams, and coastal areas. Stormwater runoff combines with failing septic systems and erosion to be primarily responsible for the 44% of Massachusetts' main rivers and 60% of assessed coastal waters failing to meet standards for fishing and swimming.

The Stormwater Initiative will implement a regulatory and outreach program designed to address the discharge of untreated stormwater runoff by promoting effective stormwater management practices. This program will simplify the existing system, which is currently inefficient for regulated parties and regulators alike. The initiative relies on existing ample statutory and regulatory authority, but improves coordination and consistency to ensure that projects with stormwater impacts are adequately reviewed. The goal is streamlined, enforceable, and predictable permitting and enforcement which will improve water quality and decrease flooding impacts, leading to both economic and environmental benefits.

Central to this effort is the development of stormwater performance standards to establish uniform criteria for adequate stormwater management and a best management practices (BMP) manual as supplementary guidance. These standards are intended to be consistent with the requirements of the Wetlands Protection Act, the Clean Waters Act, and 401 certification. The standards establish design criteria that will require implementation of stormwater management systems to reduce water quality and flooding impacts. This can be accomplished within the existing regulatory framework through policy development and clarifications by the Department. The BMP manual will link the standards to specific project types (e.g., subdivisions, parking lots) through a menu of BMPs that are appropriate. Codification may follow after an interim period to evaluate the approach and assess the results.

Generally, local conservation commissions and the Department of Environmental Protection will concentrate on assuring adequate stormwater management from new developments through the Wetlands Protection Act and the 401 Water Quality Certification Program. These permits provide an enforceable mechanism to prevent water quality impairment from stormwater discharges. The stormwater performance standards are intended to improve the review and permitting of projects at both the state and local levels. Where necessary, the Department of Environmental Protection may designate a very large project as a significant contributor of pollutants requiring a surface water discharge permit (the state equivalent of a NPDES permit).

When sites are redeveloped, regardless of whether the discharge is direct or indirect, local conservation commissions will use their authority under the Wetlands Protection Act and regulations to review projects for impacts from stormwater, provided jurisdiction is established. These sites will be subject to the stormwater standards as appropriate, to avoid disincentives to redevelopment as opposed to developing new areas. Sites proposed for redevelopment which are outside the jurisdiction of the Wetlands Protection Act pose additional problems, because the stormwater may be discharged through existing conveyances to wetlands and water bodies.

The Stormwater Initiative uses the watershed approach for addressing stormwater impacts from existing development. Existing sites with direct stormwater discharges impacting water quality will be identified through watershed water quality assessments. Addressing stormwater impacts from existing discharges raises more difficult problems than from new development. Existing discharges fall into several categories: sites not proposed for redevelopment contributing to road runoff and/or municipal stormwater systems, sites proposed for redevelopment contributing to roads or municipal systems, direct discharges from sites, direct discharges from roads, and direct discharges from municipal storm sewer systems. However, impacts from any of these sources can be identified through water quality sampling and assessment, an integral part of the watershed approach.

Municipal stormwater systems present a range of special problems, including the presence of illegal connections to sanitary sewers, large volumes of road runoff, and contaminated contributions from other sites. Often municipalities have been more concerned with the capacity of the system than with water quality. As each watershed begins the assessment process, municipalities will be assisted in improved oversight of contributors to their storm sewer systems, particularly through the implementation of municipal BMPs. Where municipalities are causing water quality impairments from their stormwater, the Department of Environmental Protection will take enforcement action, using a consent order or other tool to force improvements. Reliance on enforcement provides a necessary incentive to actually bring about water quality improvements. Enforcement will be combined with education to promote stormwater pollution prevention throughout each watershed.

Conclusion

An idealized political map might redraw town and state boundaries according to watersheds. Then an idealized stormwater program could base decision making on the particularized circumstances of each watershed. But in the search for real world solutions, the watershed approach need not ignore existing, highly successful water resource protection programs simply because they are not implemented on a watershed basis. As long as political boundaries fail to correspond to watersheds and legal authority flows to state and local government, hybrid programs of watershed and nonwatershed approaches are a necessity. The stormwater initiative designed for Massachusetts draws on the strengths of traditional existing programs and the new watershed approach, while sharpening the focus of each to generate improvements in water quality.

Regulatory References in the Code of Massachusetts Regulations (CMR)

310 CMR 10.00 Wetlands Protection Act regulations

314 CMR 3.00 Surface Water Discharge Permits regulations

314 CMR 4.00 Massachusetts Surface Water Quality Standards

314 CMR 9.00 401 Water Quality Certification regulations

(Opinions presented in this paper are those of the author and do not reflect official positions of the Department of Environmental Protection or other executive agencies or offices of the Commonwealth of Massachusetts.)

Indicators of International Progress

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Through the Great Lakes Water Quality Agreement, the Governments of the United States and Canada (the Parties) are committed "to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem." For more than two decades, numerous programs and measures have been undertaken toward this purpose. Article VII of the Agreement assigns important responsibilities in this effort to the International Joint Commission.

To fulfill its mandate to evaluate Agreement progress and provide advice to governments, the Commission requires data and information. Over many years, the Commission has carried out analysis of substantial quantities of data provided by the Parties on ambient conditions and pollutant loadings. The Commission determined a requirement for identification of indicators to evaluate Agreement progress. Consequently, in 1993 it established an Indicators for Evaluation Task Force to develop a framework within which to conduct evaluation and develop advice. From the outset the concentration of the Task Force was on integrative indicators of ecosystem integrity.

Recognizing that the ecosystem is complex and dynamic, the Task Force undertook to develop an appropriate framework and indicators which would facilitate the Commission's evaluation of Agreement progress. The framework, desired outcomes, and indicators focus principally on environmental conditions, recognizing that changes in the state of the Great Lakes ecosystem implicitly reflect the effectiveness of the actions undertaken to fulfill the obligations of the Agreement. If the framework functions as intended, it may provide useful guidance to encourage governments and others to consider a set of desired outcomes and associated indicators, as well as what data and information are necessary to evaluate progress under the Agreement, as part of the context for determining actions.

Indicators

Environmental indicators communicate information about the environment and the factors that affect it. Communication should be done so that the indicator highlights problems and draws attention to the effectiveness of current policies. Target audiences include the public as well as decision makers. To command their attention, indicators must be relevant to the problem at hand. Choosing an indicator conveys the message that it is intrinsically important. Examples of effective indicators are the Dow Jones industrial average, the gross domestic product, incident solar radiation, and pollen count.

Indicators should quantify information to make significance apparent, and simplify information to improve communication. Indicators must be easy to grasp. They often possess one of the following characteristics: either an indicator is in some way arithmetically related to some set of subordinate measurements, or an indicator is a surrogate, standing for a set of measurements that are somehow related to the chosen indicator. In most cases an indicator is highly aggregated in some manner. Indicators must be chosen and presented in such a way that a misleading impression is not created in regard to nature of the environmental condition addressed; balance is important.

In the case of the Agreement, indicators should answer such questions as:

- How clean is the ecosystem; what are present ambient conditions?
- Are trends in the right direction; how quickly are we making progress toward achieving desired outcomes?
- What and where are the problems; have cause and effect relationships been established?
- Are present programs and processes working; will we achieve desired outcomes?
- Can we detect the onset of deleterious conditions and react before significant impact occurs?

The Task Force has structured its view of indicators around the pressure-state-response (PSR) model, developed by Canada and adopted by other organizations. The main categories in the PSR framework are:

- Direct and indirect pressures, including human activities that cause environmental change.
- The physical, chemical, and biological condition or state of the natural world, plus human health and welfare.

- Responses or changes in policy or behavior by humans to address environmental conditions.

The Task Force identified indicators to help evaluate Agreement progress toward desired end points. However, it did not quantify the end points for each desired outcome; it did not develop measurable targets to tell us when we have arrived. This task appeared to be one more suited to a joint effort of the stakeholders concerned about this region.

Framework for Evaluation of Agreement Progress

The framework, which incorporates the PSR model, consists of five components: the Agreement purpose, desired outcomes, relevant data and information, stresses, and programs and policy. In applying the framework, assumptions are made about stresses, measurements, and indicators. Programs and policy are implemented accordingly. If the desired outcome is not achieved, a feedback loop ensures that programs and policies are revisited and revised accordingly to ameliorate the stress. To achieve desired outcomes the process must be iterative.

Desired Outcomes

Ecosystem integrity, including pertinent human uses and values, can be expressed in terms of desired positive outcomes, to which the public and decision makers can relate and strive to achieve. The Task Force synthesized the following nine desired outcomes from available information:

- Fishable, with no restriction on consumption of fish due to human action.
- Swimmable, with no public beaches closed due to human activities.
- Drinkable, with treated drinking water safe for human consumption.
- Healthy human populations, free from illness due to contaminants.
- Economic viability, with viable, sustainable support for regional inhabitants.
- Biological community integrity and diversity, which can function normally.
- Virtual elimination of the input of persistent toxic substances.
- Absence of excess phosphorus entering the water from human activity.
- Physical environment integrity, assuming development compatible with sustaining a normal aquatic habitat.

Collectively, this suite of nine interrelated desired outcomes provides a reasonable initial perspective of ecosystem integrity, for which indicators can be selected to evaluate Agreement progress. The intent of these desired outcomes is to restore uses, rather than just protect resources.

Data and Information

Associated with each desired outcome is a body of relevant data and information. These can reflect absolute values, rates of change, ratios, quantitative assessments, or other considerations. They should be technically and scientifically based but also understandable and relevant. Indicators provide a framework for collecting and reporting information. However, which data should be compiled, and how does one massage a mass of facts into a handful of meaningful numbers that signal whether the environment is getting better or worse? To do this, one must understand how indicators are constructed. Once accepted, they can then be used to evaluate progress, reach conclusions, and make decisions about desired changes.

Associated with each desired outcome is a "pyramid" of data and information. At the bottom of the pyramid are primary data such as PCB levels in individual fish or the phosphorus loading from a particular municipality. Such data provide the scientific underpinnings to any conclusion about achieving a desired outcome. Basic data can be statistically evaluated and aggregated to yield processed or analyzed data, such as the average annual concentration in lake trout, or the annual phosphorus loading to a lake from all municipalities. These data are used by scientists, but are not often understood by the general public. Something more is needed, to reach further up the pyramid toward outcomes.

Analyzed data can, in turn, be aggregated, combined, or integrated so as to create an indicator which represents the current state of the system. An indicator serves as a barometer of the general health of the system. Some indicators are selected as surrogates for multiple associated statistics, e.g., as the dominant vegetation might indicate a satisfactory habitat for other plant and animal species, plus adequate underlying physical-chemical conditions.

Indicators, in turn, can sometimes be aggregated into indices. An index aggregates quantities that are not necessarily commensurate into a dimensionless quantity, e.g., an air quality index. Because of their nature, indices have practical shortcomings, such as how to clearly articulate the underlying rationale, the tendency to obscure real changes in the component indicators, and how to assign weights to component indicators.

Stresses

A logical and understandable way to achieve desired outcomes is to deal with the stresses that impact the system. Stresses can take numerous forms. They can be living or nonliving and operate at the ecosystem, community, population, or individual level. To achieve desired outcomes, the Task Force identified five key stresses that must be considered:

- Biological contamination, in which the normal functioning of the ecosystem is disrupted when non-native species are introduced.

- Nutrient contamination, in which nutrients lead to eutrophication of a water body, resulting in loss of beneficial uses.

- Toxic substance contamination, in which persistent toxics are associated with a variety of problems in biota.

- Physical alterations, whereby changes in the physical landscape affect the aquatic system.

- Human activities and values, including economic, societal, and technological decisions become manifest in physical, chemical, and biological changes.

Framework and Recommendations

Putting together the concepts that were developed, the Task Force presents the following framework for each of the nine desired outcomes, with recommendations where they are noted, as follows:

Desired Outcome: Fishable

Stresses which impact this outcome include persistent toxic substances, which act via major pathways like direct industrial point discharges, diffuse discharges like surface runoff of pesticides, aerial transport of contaminants, and resuspension of contaminants from sediments back into the food chain.

The Task Force proposes fish consumption advisories as the indicator for evaluation. Lake-specific indicators should be established. The indicator is based on a large body of chemical contaminant data, which should be collected and summarized to report on the status of each lake.

Desired Outcome: Swimmable

The primary stresses affecting this outcome are associated with population growth, urbanization, and both agricultural and industrial development.

The Task Force proposes beach closings as the indicator for evaluation, measured in median number of consecutive days for a given year. Five measurements are relevant to this indicator: coliform count, turbidity, phosphorus concentrations, aesthetics, and beach characteristics.

Desired Outcome: Drinkable

The stresses which impact this outcome are microorganism occurrence, eutrophication-related taste and odor problems, and persistent toxic chemicals.

The Task Forces proposes a suite of measurements to serve as the indicators for this outcome. Although some are intended to represent treated drinking water, others must focus on the raw water source. The measurements include: bacterial count in treated drinking water; reports of human illness due to water consumption; number of warnings of water consumption limitation; incidence of taste and odor problems in treated water; reports of incidents that release chemicals which could threaten a treatment plant into the water supply; chemical concentration in the raw water; treatment plant closures; and amount of treatment at the plant, with cost necessary for additional treatment.

Desired Outcome: Healthy

Human Populations

Two principal stresses impact this desired outcome. They are microorganisms and persistent and bioaccumulative toxic substances.

The Task Force proposes a suite of measurements that can be used directly to evaluate progress toward the desired outcome: number of violations of standards for air quality, microbial, chemical, and radiological contamination; number of people affected by waterborne microbial disease; toxic contamination levels in tissues of exposed populations; toxic contamination levels in human breast milk; and hospital admissions for acute respiratory distress of children under one year of age.

Desired Outcome: Economic Viability

Stresses that affect economic viability include: overall regional production and economic activity; relative competitiveness of regional producers; demand for regional products; health of the resource base; world commodity issues; income maintenance, retraining, and other employment policies; and other exogenous economic social and policy actions.

The Task Force proposes total employment in the Great Lakes basin as the indicator to evaluate progress toward the desired outcome. Measurements to support the indicator are the number of people seeking employment, and the percentage of the work force that is employed.

Desired Outcome: Biological Community Integrity and Diversity

Principal stresses of concern are: destruction of habitat important to desirable species; introduction of exotic species; overharvesting which reduces populations below minimum viable level; introduction of toxic contaminants; and introduction of excess nutrients.

The Task Force proposes the following suite of measurements to evaluate progress toward the desired outcome: presence and abundance of selected key species including a top predator, a mid-trophic level, and at the food base; quantity and quality of habitat types; number and abundance of endangered native species; cumulative number and abundance of exotic species introduced; fish harvest statistics vs. spawning biomass levels; toxic contaminant levels in selected fish and fish-eating birds; and ambient phosphorus concentrations.

Desired Outcome: Virtual Elimination of Input of Persistent Toxic Substance

Persistent toxic substances are identified directly as an important stress on the ecosystem. The Task Force proposes a suite of measurements to evaluate progress toward achieving the desired outcome. The measurements include: quantities of persistent toxic substances produced, used, and discarded; total loadings of toxic substances to the ecosystem; programs and measures undertaken by governments, business, and others to reduce the use of toxic substances; concentration of toxic substances in water, sediment, etc.; concentration of toxic substances in top predator fish and fish-eating birds; biochemical measures of change at the tissue level, e.g., endocrine function; and changes in the development or survival of species, e.g., deformities.

Desired Outcome: Absence of Excess Phosphorus

Excess nutrients are identified directly as the stress affecting the desired outcome. The Task Force proposes a suite of measurements to evaluate progress toward achieving the desired outcome. The measurements include: ambient phosphorus concentrations in selected areas of the lakes, e.g., nearshore areas; algal blooms; phosphorus loading and effluent data for point and non-point sources; costs for additional mitigation of nutrient loadings; and changes in recreational activities due to effects of excess nutrients.

Desired Outcome: Physical Environment Integrity

Stresses that impact this desired outcome include: actions that alter habitat, e.g., infilling; land use changes, e.g., development for human purposes; and alterations in shorelines and tributaries.

The Task Force proposes the following suite of measurements to evaluate progress toward the desired outcome: quantity and quality of habitat for critical components of the food web; quantity and quality of wetlands; quantity and quality of stream base flow; number and extent of engineered land/water interfaces, e.g., dams, weirs, diversions; and land use practices and watershed management practices.

Conclusions

The Task Force recommends a number of conclusions that result from this effort. They include that

Governments, the Commission, and others adopt the framework, the nine desired outcomes, and the indicators and measurements that have been developed. In addition, that a strategy should be created to implement the desired outcomes. Other conclusions are: further study to link human health to exposure to contaminants; surrogate measures for human health are needed in other species; seeking consensus on biological integrity and diversity; study of a possible desired outcome for a balanced nutrient regime; developing a uniform sport fish consumption advisory, and uniform criteria for water suitable for swimming; and development of indices suitable for communicating the status of the ecosystem to the general public.

References

International Joint Commission. (1995) White Paper-Indicators to Evaluate Agreement Progress, Revised Draft. Prepared by the Indicators for Evaluation Task Force.

Lake Superior Binational Program: An Ecosystem Approach to Protection of Lake Superior Through Development of a Lakewide Management Plan

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The history of the Binational Program to Restore and Protect Lake Superior goes back to the 1989 International Joint Commission (IJC) meeting in Hamilton, Ontario, although the foundations for the program were actually laid by the 1972 Great Lakes Water Quality Agreement (GLWQA) between the United States and Canada (amended in 1978 and 1987). The IJC is an advisory board on boundary water issues. Every 2 years, a growing community of interested citizens and stakeholders around the Great Lakes gathers for a public IJC meeting on Great Lakes water quality. At the 1989 meeting the public showed strong support for a program to demonstrate "zero discharge" of persistent bioaccumulative toxic substances. In response to this support, the IJC recommended that the governments undertake a zero discharge demonstration program for Lake Superior. The federal governments of the United States and Canada, together with Minnesota, Michigan, Wisconsin, and Ontario, responded by launching the Binational Program, an innovative program of ecosystem management for Lake Superior. The program was announced at the 1991 IJC meeting.

Pollutants targeted for zero discharge	
Mercury	DDT
PCBs	Dieldrin
2,3,7,8-TCDD (dioxin)	Toxaphone
Octachlorostyrene	Hexachlorobenzene
Chlordane	

The Binational Program is a partnership between the governmental jurisdictions around Lake Superior, a group of highly involved stakeholders (the Lake Superior Binational Forum), and the wider public. The Lake Superior Binational Forum is an advisory group with membership representing a wide range of interests, including municipalities, native organizations, industries, environmental advocacy groups, the academic community, and other citizens.

Public support for a Lake Superior zero discharge demonstration program was driven by long-standing concern about toxic substances in the Great Lakes. Although Lake Superior remains the most pristine of the Great Lakes, it is not without environmental problems. Fish consumption advisories are issued for lake trout and other species because of mercury and several organochlorine compounds. Contaminants in fish are of particular concern for tribal subsistence fishers, who receive greater exposure than the average population. The Lake Superior watershed, with its relatively low population and limited industrial development, was considered to be the best candidate for the demonstration program. A slogan used by zero discharge supporters at the IJC meetings was "If not Lake Superior, where? If not now, when?"

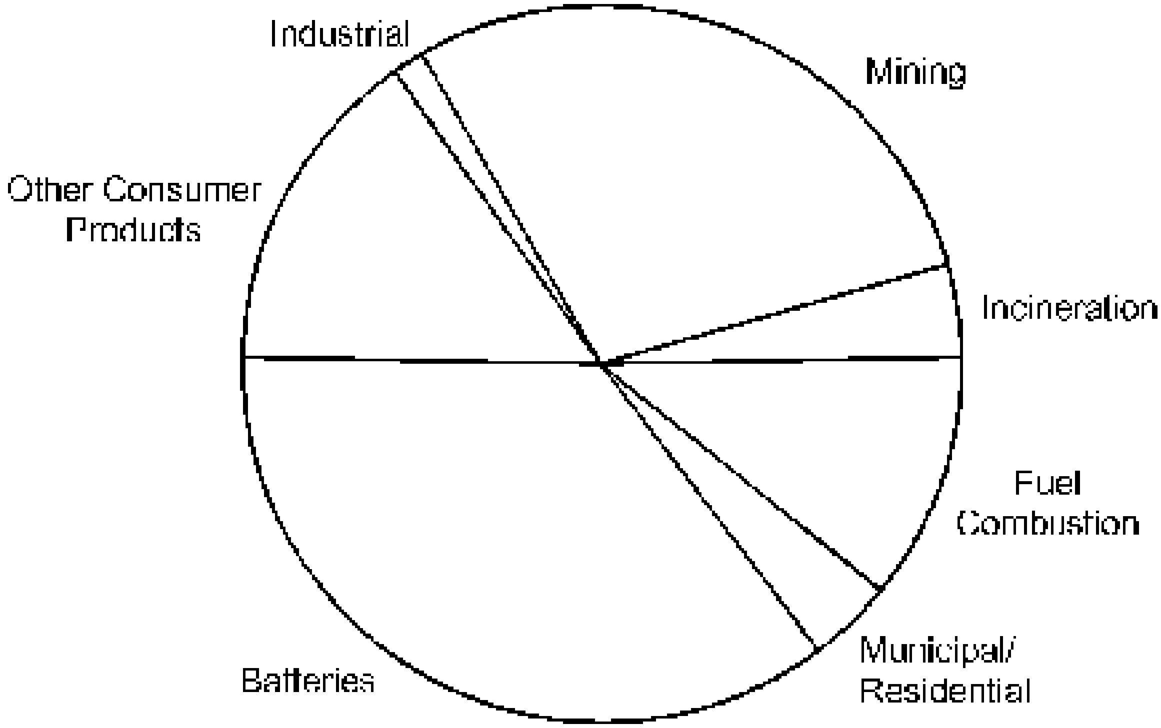

Figure 1. 1990 estimated use, generation, and release of mercury.

The nine pollutants targeted for zero discharge are listed to the left. They are bioaccumulative and persistent and are found in the food chain at levels causing harm.

The Binational Program encompasses two major activities: the zero discharge demonstration program for designated persistent toxic substances and a broader program of ecosystem management and protection. The Binational Program uses the Lakewide Management Plan (LaMP) mechanism outlined in the GLWQA to report progress, but in Lake Superior the broader program will address resource issues. The GLWQA calls for LaMPs to embody a comprehensive ecosystem approach to restoring and protecting beneficial uses. The GLWQA charges LaMPs to identify critical pollutants, and to develop schedules and strategies for pollutant load reductions to restore beneficial uses.

Resource management issues (e.g., fisheries, wildlife, and forestry) and nonchemical stressors such as exotic species and habitat loss are important components of the Lake Superior program. The partners are identifying habitat sites throughout the Lake Superior watershed that are critical for ecosystem health. Habitat and toxics concerns will be integrated in later stages of the LaMP.

Primary agencies developing the Lake Superior LaMP
• Environment Canada
• United States Environmental Protection Agency
• Ontario Ministry of Energy and Environment

• Michigan Department of Natural Resources
• Minnesota Pollution Control Agency
• Wisconsin Department of Natural Resources

The first stage of the Lake Superior LaMP went out for public review in 1993 and was submitted to the IJC in 1995. The Stage 2 LaMP, which establishes load reduction targets and schedules for critical pollutants, is under way. These reduction schedules will serve as goals for the management strategies to be developed during the third stage of the LaMP.

Stage 1 identified 22 critical pollutants based on impaired beneficial uses, ecosystem objectives in the GLWQA, and other criteria of environmental quality. The 22 critical pollutants include the 9 targeted for zero discharge. For these nine, atmospheric deposition is a major path of entry to the lake, where they bioaccumulate and are responsible for fish consumption advisories. Other critical pollutants were identified based on impairments (contaminated sediment, degraded benthic communities, and fish tumors or deformities) in near-shore and harbor degraded areas. Of primary concern among these pollutants are polycyclic aromatic hydrocarbons (PAHs) and cadmium because of their relatively widespread distribution.

The critical pollutants are grouped by the environmental and management goals that will guide management strategies. "Zero discharge" is a strategy to work toward the conceptual goal of virtual elimination from the environment, and nine pollutants are in the zero discharge category. The environmental goal for other critical pollutants is to restore the beneficial uses that they currently impair. Some other pollutants identified by the LaMP are in a third category, "preventative" chemicals. These chemicals have not been found at concentrations causing harm in the Lake Superior basin, but they have the potential for harm if released to the environment. The management goal for these chemicals is to prevent their release to the Lake Superior environment.

Once the critical pollutants had been identified, information on their sources and loadings was compiled. In Stage 1 measured data for facility emissions within the Lake Superior watershed were consolidated. Most of the data had been collected for regulatory compliance purposes, limiting their application to the LaMP. Data reporting requirements varied between state and provincial jurisdictions, and only regulated compounds were reported. In the absence of consistent measured data on emissions or extensive monitoring data on all inputs to the lake (such as tributary loadings, atmospheric deposition, and sediment-water exchange), estimates of chemical use, generation, and release within the watershed were used to help guide the strategy for chemical reduction. Measured monitoring data are still integrated into the program where available.

Stage 2 work began with the nine pollutants targeted for zero discharge. Through 1994 and 1995, the Binational Forum advisory group worked with the governments and used other sources of information to develop recommended load reduction schedules. The governments, in turn, initiated public discussions. The Forum's recommendations provided an excellent starting point for these broader discussions aimed at developing consensus-based goals. An experimental effort like the zero discharge demonstration program depends on the engagement and support of the local citizenry, the business community, and other stakeholders.

Mercury and polychlorinated biphenyls (PCBs) provide good illustrations of the approach being taken with the Lake Superior LaMP. Mercury, a naturally occurring element, is used in many products and applications. It is used in thermometers, batteries, electrical switches, barometers, lamps, pharmaceuticals, laboratory reagents, and pigments. It is released inadvertently by a number of combustion, mining, and manufacturing processes.

Work for the Stage 2 LaMP estimated the use, generation, and release of mercury. These estimates will help in setting priorities for action. The estimates showed that consumer products, including dry cell batteries, accounted for about half of the total mercury "pool" in the Lake Superior basin (1990). The pool represents a mixture of estimated environmental releases and potential future releases, such as consumer products and other waste materials placed in landfills or incinerated, which might enter the environment over time. Other major sources of mercury release are mining and fuel consumption. The Forum recommended a reduction schedule for anthropogenic mercury loadings to water, air, and other sources both within and outside the watershed. A 60 percent reduction in loadings by the year 2000 was recommended (Table 1). Although the initial 60 percent reduction goal for mercury is aggressive, the Forum considered it achievable based on successes in limiting mercury use in batteries and implementing process changes in many industries.

PCBs were once widely used as dielectric fluids in transformers and capacitors, with peak production in the United States in 1970. PCBs were also used as lubricants and in plastics, paints, inks, and carbonless copy paper. While the use of PCBs in existing equipment is allowed in both the United States and Canada, manufacture and new uses ceased in the late 1970s. Because the production of PCBs has been banned, efforts to estimate the potential PCB loadings have focused on inventories of capacitors and transformers containing PCBs. In 1991, a total of 1,026 tonnes of PCBs were estimated to be in use or storage in the Lake Superior watershed. Estimates show that industries house more PCBs than do utilities in the watershed. The destruction of PCBs will eliminate an estimated 41 kilograms per year released through spills. The Forum recommended a destruction schedule for "accessible" PCBs, such as those in use or storage, as opposed to PCBs scattered in the environment.

Guiding principles recommended for government actions include:

- Stress pollution prevention for mercury.
- Provide incentives to remove mercury from fuel emissions.
- Eliminate nonessential uses of mercury.
- Remove PCBs at the end of the useful life span of equipment.

- Emphasize destruction of PCBs rather than storage.
- Encourage development of innovative technology and demonstration projects.

Table 1. Summary of Forum-recommended schedules: mercury and PCBs.

Pollutant	Baseline	2000	2005	2010	2020
Mercury	1990	60% reduction in loadings from in-basin and atmospheric sources	-	80% reduction in loadings from in-basin and atmospheric sources	Virtual Elimination
PCBs	1995	Destroy 33% of accessible PCBs	Destroy 60% of accessible PCBs	Destroy 95% of accessible PCBs	Virtual Elimination

The management strategies to work toward these reduction goals will be developed during the third stage of the LaMP. However, actual progress in the Binational Program does not fall neatly into the LaMP stages. Progress under various areas is dependent on funding, agency priorities, market forces, public support, and political will. Elements of the eventual strategy for mercury and PCB reductions are already being implemented as part of the pollution prevention strategies under the Binational Program. Efforts to develop better information on mercury and PCB loadings and their behavior in Lake Superior are ongoing. Activities have included expanded household hazardous waste collection programs, consumer and business education, state legislation to ban the use of mercury in toys and other frivolous uses, and pilot projects to target hospitals and dental offices to reduce mercury waste and segregate it from waste streams going to wastewater treatment plants and incinerators, from which it is largely released to the environment. Also ongoing are discussions with utilities and legislators concerning energy conservation.

The zero discharge demonstration represents a societal goal to prevent the nine designated pollutants from being discharged or emitted. The issue is not how many molecules are permissible or detectable in a discharge. The key is pollution prevention_ensuring that these chemicals or their precursors are not used in processes or products so they are not released to the environment. These are issues for society at large rather than only issues of treatment technology for industries with point source discharges. The challenge is to develop chemical reduction goals with broad public support and to form strategies to work toward those goals to protect Lake Superior. Lessons learned in the Lake Superior basin will lay the groundwork for application of

Great Lakes Remedial Actions Plans: Toward Ecosystem-Based Management of Watersheds

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Over a century of human population growth and economic development has led to degradation of the Great Lakes Basin Ecosystem and impairment of its beneficial uses. Currently, there are 42 degraded areas of the Great Lakes or Areas of Concern (AOCs) where one or more beneficial uses are impaired. Examples of AOCs include: Cuyahoga River, Cleveland, Ohio; Hamilton Harbour, Ontario; Fox River-Green Bay, Wisconsin; Niagara River, New York and Ontario; and Rouge River, Michigan.

The United States and Canada have a long history of assessing and tracking the ecosystem status of the Great Lakes and working cooperatively to restore and maintain their integrity under the auspices of the 1909 United States-Canada Boundary Waters Treaty, the International Joint Commission (IJC), and the Great Lakes Water Quality Agreement (GLWQA). For each of the AOCs, a remedial action plan (RAP) is being developed to identify and implement key actions needed to restore beneficial uses. The concept of RAPs originated from a 1985 recommendation of the IJC's Great Lakes Water Quality Board. The Board found that despite implementation of regulatory pollution control programs, a number of beneficial uses (e.g., unrestricted human consumption of fish, successful reproduction of certain sentinel wildlife species, fish and wildlife habitat) were not being restored, and recommended that comprehensive and systematic RAPs be developed and implemented to restore all beneficial uses in AOCs.

The 1987 Protocol amending the GLWQA formalized the RAP program and explicitly defined AOCs as specific geographic areas that fail to meet the general or specific objectives of the GLWQA where such failure has caused or is likely to cause impairment of beneficial use or of the area's ability to support aquatic life (United States and Canada, 1987). Impairment of beneficial use means a change in the chemical, physical, or biological integrity of the Great Lakes ecosystem sufficient to cause any of the following 14 use impairments:

- restrictions on fish or wildlife consumption;
- tainting of fish and wildlife flavor;
- degradation of fish and wildlife populations;
- fish tumors or other deformities;
- bird or animal deformities or reproductive problems;
- degradation of benthos;
- restrictions on dredging activities;
- eutrophication or undesirable algae;
- restrictions on drinking water consumption, or taste and odor problems;
- beach closings;
- degradation of aesthetics;
- added costs to agriculture or industry;
- degradation of phytoplankton and zooplankton populations; or
- loss of fish and wildlife habitat.

Annex 2 of the Great Lakes Water Quality Agreement states that RAPs shall embody a systematic and comprehensive ecosystem approach to restoring and protecting uses in AOCs (United States and Canada, 1987). In addition, the Agreement states that the Parties, in cooperation with State and Provincial

Governments, shall ensure that the public is consulted in all actions undertaken pursuant to RAPs. The RAP Program has been described as an experiment in adaptive, environmental management where flexible, locally-designed, ecosystem approaches are being used to build the capacity to restore beneficial uses.

An ecosystem approach accounts for the interrelationships among land, air, water, and all living things, including humans; and involves all user groups in comprehensive management (Hartig and Vallentyne, 1989). Currently, 40 of the 42 AOCs have either a stakeholder group, coordinating committee, or comparable RAP institutional structure broadly representative of environmental, economic, and societal interests in AOCs. These RAP institutional structures are established to: help implement an ecosystem approach; ensure broad-based public participation; help coordinate and facilitate RAP development, audit RAP implementation, and track progress; and help build the capacity to restore beneficial uses.

A key concept in the RAP process is accountability for action. This is established through open sharing of information, clear definition of problems (including identification of indicators to be used in measuring when the desired state is reached), identification of causes, agreement on actions needed, and identification of who is responsible for taking action. From this foundation, the responsible institutions and individuals can be held accountable for progress.

RAPs require cooperative learning that involves stakeholders working in teams to accomplish a common goal under conditions that involve positive interdependence (all stakeholders cooperate to complete a task) and individual and group accountability (each stakeholder is accountable for the final outcome). For RAPs to be successful, they must:

- be cleanup- and prevention-driven, and not document-driven;
- make existing programs and statutes work;
- cut through bureaucracy;
- elevate the priority of local issues;
- ensure strong community-based planning processes;
- streamline the critical path to use restoration; and
- be an affirming process.

Based on a basin-wide review of progress in the Great Lakes RAP program, RAP processes are most effective if they are mission-driven (i.e., a focus on ecosystem results and restoring uses) and not rule-driven. Successful RAP processes empower institutional structures to pursue their mission of restoring impaired uses. Empowerment of RAP institutional structures can be demonstrated by: a focus on watersheds or other naturally-defined boundaries to address upstream causes and sources, and obtain commitments from within the watershed for implementation; an inclusive and shared decision-making process; clear responsibility and sufficient authority to pursue the mission; an ability to secure and pool resources according to priorities for action using nonprofit organizations or other creative mechanisms; flexibility and continuity in order to achieve an agreed-upon road map to use restoration; commitment to broad-based education and public outreach; and an open and iterative RAP process that strives for continuous improvement (Hartig and Law, 1994a).

In essence, the RAP process is building the capacity to restore beneficial uses in the watersheds of Great Lakes AOCs. RAPs are employing a combination of: human elements and strategies (e.g., empowerment, long-term vision/mission driven, shared decision-making); tools and techniques (e.g., pollution prevention, habitat rehabilitation and enhancement, remediation of contaminated sediments and hazardous waste sites); and management support systems (e.g., ecosystem performance measures, geographical information systems, decision support systems, information sharing) to restore and maintain both human and nonhuman uses in degraded watersheds (Hartig et al. 1995).

Considerable progress is being made in re-orienting Great Lakes decision-makers to a more inclusive and holistic RAP process that accounts for linkages, shares decision-making power, achieves local ownership, and focuses on ecosystem results. The development and implementation of RAPs represent the first opportunity, on a broad and practical scale, to implement an ecosystem approach consistent with the long-term goal of sustainable development (i.e., development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs). Both an ecosystem approach in RAPs and sustainable development recognize the fundamental roles and interrelationships of economy, society, and environment in sustaining the quality of ecosystems. Table 1 presents a list of critical elements to help government agencies guide efforts toward greater use of an ecosystem approach in watershed management (Coape-Arnold et al., 1994). In a time when resources are becoming scarce, such an approach has proven an effective mechanism to coordinate programs and harness and leverage resources.

Table 1. A list of critical elements to help government managers guide efforts toward ecosystem-based management of watersheds.

- Adopt watershed/bioregion as primary unit for management
- Develop partnership agreement or other mechanism for cooperative, multi-stakeholder management and ensure commitment of leaders
- Identify and empower an "umbrella" watershed organization for coordination
- Develop long-term vision, goals, and quantitative targets for "desired future state" of ecosystem
- Reach agreement on a set of principles to guide decision-making process
- Ensure all planning processes in watershed acknowledge vision, goals, quantitative targets, and principles
- Establish geographical information system (GIS) and decision support system capability in watershed organization
- Compile data and information for input into GIS and ensure strong commitment to research and monitoring to understand ecosystem and fill knowledge and data gaps
- Set priorities that target major causes of ecosystem health risks, evaluate remedial and preventive options, implement preferred actions, and monitor effectiveness in an iterative fahsion (i.e. adaptive management)
- Ensure full costs and benefits (i.e. economic, societal, environmental) are assessed for each project in watershed
- Consolidate capital budgets and pool resources, as necessary, to move high priority project forward
- Create the framework and condidtions for private sector involvement and capitalize on its enterprise, initiative, creativity, and capability for investment
- Utilize market forces and economic incentives to achieve ecosystem objectives
- Commit to public, state-of-the-environment and economy reporting every 2 - 5 years to measure and celebrate ecosystem progress, and to measure stakeholder satisfaction
- Ensure commitment to broad-based, ecosystem education and human resource development throughout process

Governments are learning that all stakeholders have something to offer and can play significant roles in RAPs. Through government and community-based partnerships, RAPs are attempting to overcome environmental decision-making gridlock by developing a coordinated, multi-stakeholder response to restoring impaired beneficial uses in AOCs (Hartig and Law, 1994b). Sustaining the RAP process will require continued public involvement, ensuring long-term commitment to research and monitoring, achieving effective communication and cooperation, creatively acquiring resource commitments, and building a record of success. Both short- and long-term milestones must be celebrated. Examples of milestones include: government management actions; remedial and preventive actions by sources; changes in discharge quality; reductions in contaminant loadings; changes in air/water/sediment concentrations; reductions in bioaccumulation rates; biological recovery; use restoration; and improved suitability for human use of resources.

Stakeholders have been instrumental in helping governments be more responsive to and responsible for restoring uses in AOCs. Further, stakeholders have been the primary catalyst for implementing actions which have resulted in ecosystem improvements. In essence, RAPs are reinventing the role of government in management of Great Lakes AOCs. Such broad-based partnerships among diverse stakeholders can best be described as a step towards grassroots ecological democracy in the Great Lakes Basin (Hartig and Zarull, 1992).

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The National Water Quality Initiative: Lessons Learned From The Water Quality Demonstration Project-East River

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In 1990 a 221 square mile area of northeastern Wisconsin became one of 16 demonstration projects nationwide established by the United States Department of Agriculture (USDA) under the President's Water Quality Initiative. The project, known as the Water Quality Demonstration Project-East River (WQDP-ER), was a five year effort that set out to determine whether farmers would voluntarily adopt innovative pollution protection practices to protect or improve water quality. To determine the impact of the WQDP-ER project a 1990 baseline survey was conducted that recorded the management practices being used by farmers in the watershed. In 1995, a follow-up survey and detailed staff records were used to measure the extent to which practices introduced by the project had been adopted by area farmers.

Background

This federally funded project encompassed the East River watershed, which feeds Green Bay on Lake Michigan (Figure 1). Three-quarters of the area is rural, including dairy farms, smaller suburban communities, villages and the city of Green Bay. Green Bay was identified as a "Great Lakes Area of Concern" by the International Joint Commission and the State of Wisconsin due to ongoing pollution problems that endanger aquatic life, restrict recreation and other water uses (Wisconsin Department of Natural Resources, 1988).

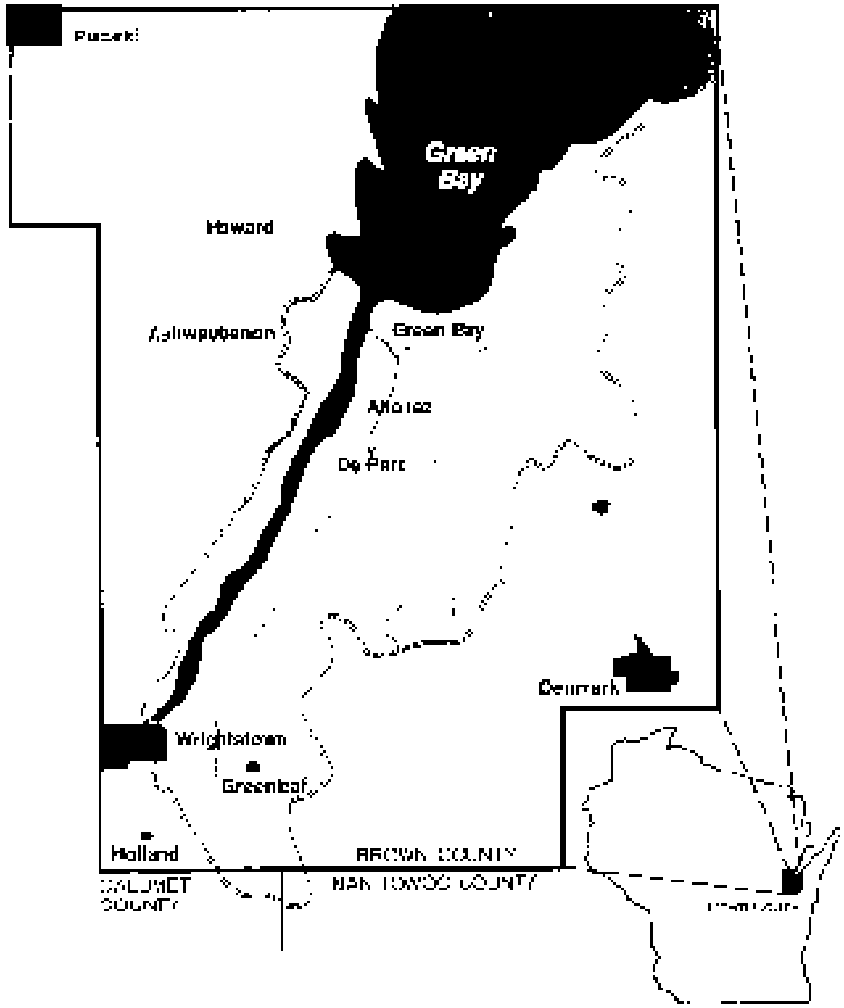

Figure 1. The East River Watershed

Heavy phosphorus loading to East River has contributed to algae growth in the waters of Green Bay, while pesticides have been found in bay sediments. USGS monitoring studies (Hughes, 1988) in the basin found that the East River is a major source of sediment and phosphorus, contributing 11 percent of the total suspended sediment and 9 percent of the total phosphorus load transported into lower Green Bay. USGS river monitoring also detected widespread bacterial contamination originating from livestock wastes and other sources.

Agricultural Impacts

When the WQDP-East River began, a 1990 baseline survey of farmers in the watershed showed that many were applying more fertilizer and pesticides than necessary. Roughly 84 percent were applying more phosphorus than recommended by University of Wisconsin-Extension, while 61 percent were applying too much nitrogen (Nowak and Shepard, 1991). Most second and third year corn fields were being treated with rootworm insecticide, even when insect problems weren't detected. Additionally, in 1990, farmers were applying 215 pounds of nitrogen per acre in the production of corn when average University recommendations called for 160 pounds of nitrogen per acre. These studies also found that nitrogen crediting from land-spread manure would allow for further reductions in purchased nitrogen--as much as 80 pounds per acre--while maintaining crop yields. And by using manure to meet crop nutrient needs, less phosphorus is purchased--thus contributing to lower phosphorus loading in local waters.

The Goals of The Water Quality Demonstration Project-East River

The overall goal of the WQDP-ER was to encourage farmers to adopt research-based practices that protect and improve groundwater and surface water quality while maintaining or increasing farm profitability. To accomplish this goal WQDP-ER staff initiated educational programming on integrated crop management (ICM). ICM helps farmers minimize the potential for water pollution from farm chemicals. With ICM, farmers determine fertilizer and pesticide requirements on a field-by-field basis. ICM is often defined by a broad set of best management practices that include soil testing, crediting nutrients from manure application and prior alfalfa crops, the use of crop scouting, and the application of pesticides only if the damage caused by the pest exceed the cost of the treatment.

The Water Quality Demonstration Project Response

WQDP-ER staff responded through one-on-one consultations with farmers, field days and tours to promote a number of ICM practices. The project also offered workshops for farmers and agribusiness professionals that helped them better understand crop scouting techniques and proper pesticide application. Local farm visits with producers and private sector agronomists were used to showcase nutrient management practices such as calibration of manure spreaders and manure nutrient content analysis. Weekly letters, informational mailings, fact sheets and brochures all helped keep producers more informed of local insect counts and other specific issues about how ICM works in the watershed.

When WQDP-ER staff teamed up with local crop consultants, farmers were assisted in writing farm specific ICM plans. Each fall, ICM practicing farmers and their crop consultants gather information for the coming crop season, pulling soil nutrient samples and scouting fields for insects and weeds. This information is then used to plan fertilizer and pesticide application on a field-by-field basis.

Results and Discussion

After five years of intensive programming on ICM, a post-project evaluation was conducted. A random group of farmers was selected from the original 1990 baseline survey. The results indicate that many farmers had changed their management practices. In doing so, they had reduced excessive fertilizer applications and decreased the threat of agricultural pollution (Figure 2). Specifically, by 1995 farmers in the project reduced their total nitrogen application (per acre) by an average of 37 percent since the WQDP-ER began in 1990.

ICM practices in the WQDP-ER project area focused extensively on the crediting of on-farm sources of nitrogen and phosphorus. The farmers who were able to proportionately reduce their commercial nitrogen applications based on nitrogen crediting from alfalfa crop increased from 44 percent in 1990 to 81 percent in 1995. Similarly, the farmers taking credits from manure applications and reducing their commercial nitrogen applications increased from 20 percent in 1990 to 28 percent in 1995 (Figure 3).

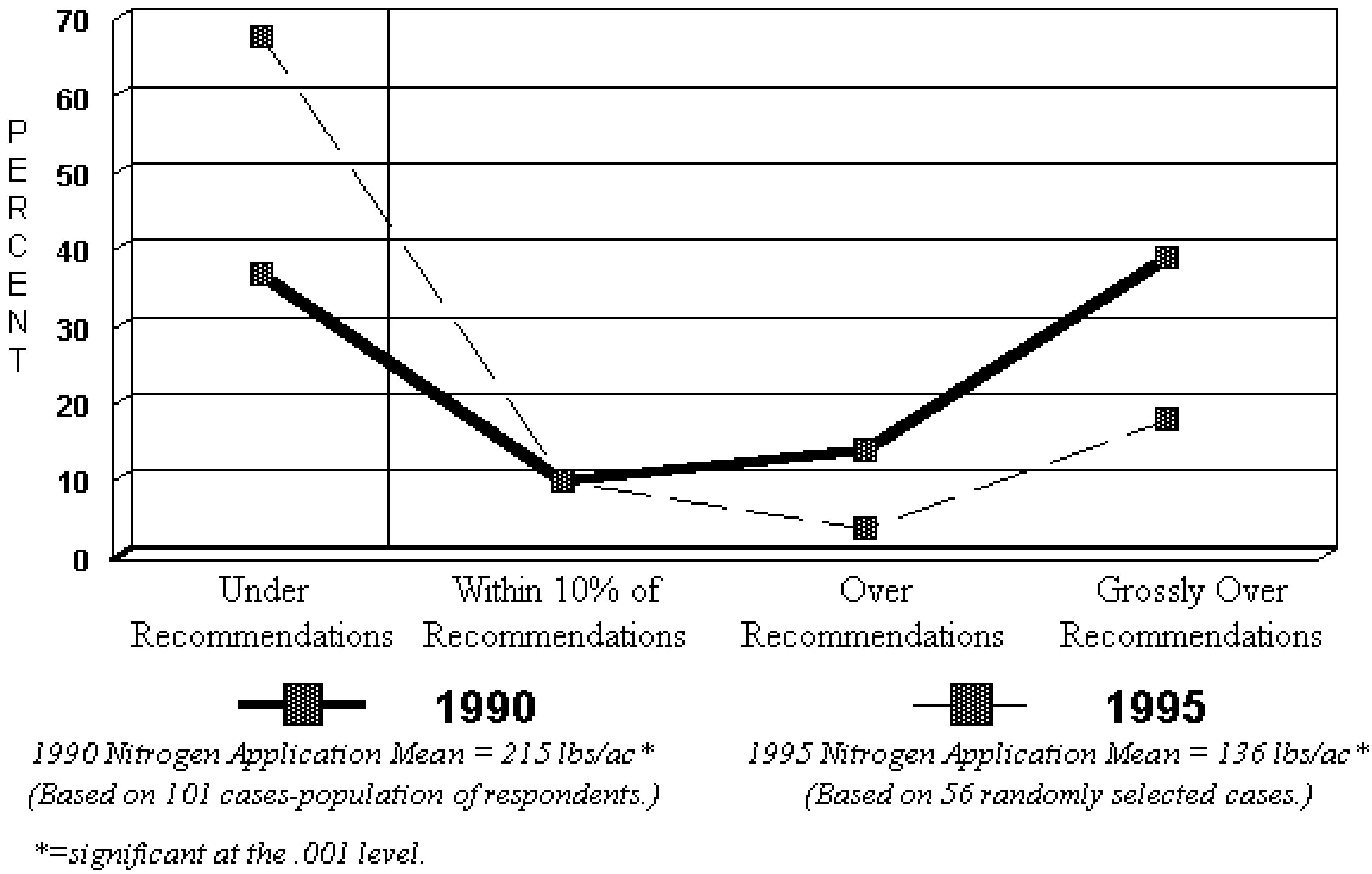

Figure 2. Nitrogen Application in the East River Watershed

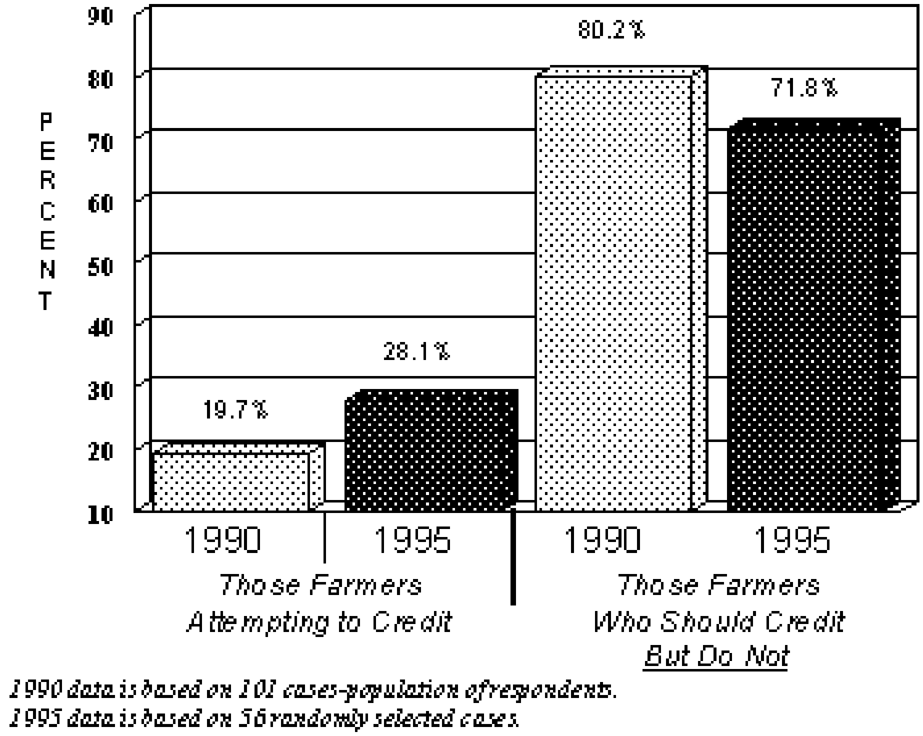

Figure 3. The Crediting of Manure - Nitrogen in the Production of Corn

When the project began in 1990, ICM was virtually unknown. By 1995, 52 farms covering 16,000 acres were enrolled in the WQDP's ICM program. At least 50 more farmers in the watershed were using ICM practices through other programs, bringing the total of ICM applied acres to more than 22,000. Moreover, farmers participating in the ICM program saved an average of $5,000 a year in fertilizer and pesticide costs.

Acknowledgments

The WDQP-ER was a cooperative venture for the U.S. Department of Agriculture, merging technical, educational and financial assistance from the University of Wisconsin-Extension (UW-Extension part of the federal Cooperative Extension Service), the federal Natural Resources Conservation Service (formally the Soil Conservation Service, SCS) and the federal Consolidated Farm Service Agency (formally the Agricultural Stabilization and Conservation Service, ASCS). This summary also reflects the valuable work by WQDP-ER project staff.

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Columbia River Basin Model Watersheds -- Bonneville Power Administration's Implementation Role

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Web Note: *Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

Introduction

Bonneville power Administration (BPA) was created by Congress in 1937 to market and deliver electricity generated by dams on the Columbia River system. Other dam design purposes included flood control, navigation, irrigation and flat water recreation. Over a period of 66 years 30 federal dams were constructed on the Columbia River and a major tributary, the Snake River. Five other major dams were also constructed by public utility districts for a total of 35 major dams on the mainstem Columbia and Snake Rivers. The federal dams are operated and maintained by the U.S Army Corps of Engineers (Corps) and the U.S Bureau of Reclamation. This includes all major dam activities such as power generation, flood control, navigation, irrigation and fish passage facilities. BPA hydroelectric power sales fund a majority of the operation and maintenance costs of these programs.

In 1980 Congress passed the Pacific Northwest Electric Power Planning and Conservation Act (Act) which created the Northwest Power Planning Council (NPPC). The Act's purpose was to create an entity to guide the Northwest region, which included the states of Montana, Idaho, Washington and Oregon, in coordinated planning for electric power production and conservation, and fish and wildlife mitigation of the effects of federally operated Columbia and Snake River dams. Section 4.[h][10][A] of the Act authorized BPA funding of the fish and wildlife mitigation program.

The NPPC consists of two governor appointed members from each of the four states, their support staff, and a central support staff for power production planning and fish and wildlife mitigation. The NPPC, in cooperation with the regional fish and wildlife program managers and other interested entities, developed a Fish and Wildlife mitigation plan (FWLP) two years after the Act was created, and amends the FWLP on a five year cycle or as needed.

Model Watershed Program Development

The most recent FWLP amendment phase began in 1990. The need for short term decisions, plus longer term decision making, necessitated a phased amendment process. Phase One, or Early Implementation Projects, was passed by the NPPC on August 21, 1991. Measure 3.1 Model Watersheds, directed BPA through the states of Washington, Idaho and Oregon, to fund the implementation of a watershed planning and implementation program.

The guiding principles of the Model Watershed measure were:

1. Each state would select a lead state agency and develop a process for watershed selection.
2. Bonneville would provide "initial" funding for a model watershed coordinator and associated staff.
3. Each watershed would develop a watershed plan with the following major elements:
4. Identify watershed entities which have a role or interest in the fisheries and natural resource management of the watershed
5. Identify how each of these entities could best be used in the development of a watershed plan, and organize an oversight and a technical group to guide the watershed plan development
6. Develop a set of watershed plan goals and objectives
7. Identify existing information resources to conduct a watershed assessment
8. Identify major gaps in information base and develop a plan to obtain this information
9. Set out a path to fill major information gaps and address conflicts
10. Analyze information and determine major limiting factors to in-basin anadromous fish production

11. Develop an implementation and monitoring and evaluation plan to address the anadromous fish production limiting factors

12. Seek funding sources for project implementation

13. Begin implementation of projects, conduct M&E, and modify plan as needed. Involve volunteer and educational institutions when possible.

The basic premise behind the Model Watershed (MWS) program was that anadromous fish habitat mitigation could best be accomplished on the watershed level with plans that were built from the ground up, with involvement from all watershed entities. BPA had invested approximately $39 million in anadromous fish habitat restoration projects through 1990. This investment had two major weaknesses. First, most of the projects had been developed by state fish and wildlife agencies, tribes or federal land management agencies without watershed level analysis to guide their prioritization and selection. Generally the projects represented worthwhile habitat restoration efforts, but they were focused on small areas for specific habitat issues. On a scale the size of the Columbia River basin, project implementation could have appeared as a random game of darts. Secondly, there was little or no participation from private land owners. Many of the resource challenges existed on private lands, and often a majority of the best, or potentially best habitat was on private lands. Participation by state and federal agencies was also variable within and between states depending upon their view of habitat mitigation. These factors lead BPA and many other agencies to propose and support the implementation of the MWS program for the Columbia River basin.

Each of the three states chose one or more watersheds through a selection process which generally involved a consortium of state agencies. In the first year of the MWS program Asotin Creek was chosen from Washington, Grande Ronde River from Oregon and Idaho chose a three neighboring watersheds in the upper Snake drainage, i.e. Lemhi, Pahsimeroi and East Fork Salmon Rivers. In the second year of the MWS program, Washington added two neighboring watersheds, i.e., the Tucannon River and Pataha Creek, a major tributary to the lower Tucannon River. See Figure 1.

In Washington and Idaho the lead state agency was the Soil and Water Conservation Commission. They in turn worked with the local Conservation District to establish the MWS coordinator positions. The Commissions and Districts jointly choose to enlist existing District or Natural Resource Conservation Service (NRCS) employees. This choice utilized the existing expertise and coordination of those best able to work with the private land owners as well as the state and federal agencies and tribes. In Oregon, the Grande Ronde already had a group which has been established by the Bureau of Reclamation and the Department of Water Resources to deal with water management challenges. This group was in the process of hiring a coordinator. It was decided to combine the two programs and resources.

For the most part, planning on a watershed scale, with an emphasis on anadromous fish was a new process for these watersheds. The exceptions were in the Lemhi and Tucannon River watersheds. The Lemhi watershed had an intensive existing program to deal with irrigation water management and screening of irrigation diversions. The Tucannon watershed had an existing watershed plan developed under Public Law 566_NRCS's small watersheds program. Each of these plans had ingredients of a comprehensive watershed plan, but generally lacked one or more details such as a review of the instream habitat quality or riparian habitat information. Each watershed varied in its complexity and challenges to develop a watershed plan. Table 1 lists some of the components. Grande Ronde Model Watershed: The Grande Ronde Model Watershed (MWS) is by far the most complex. It has the largest size, number of sub-watersheds, and miles of stream. It has two diverse counties and major interest from two tribes. Participation has been high from the major landowner groups and general public participation has grown. Without a lead state agency, the watershed has had to rely upon a wide variety of sources to gather and compile information and ultimately produce a watershed plan. The Bureau of Reclamation has been a major funding participant in one of the counties, in cooperation with BPA to fund the watershed plan development and implementation. This plan has required an overall umbrella analysis, followed by detailed sub-basin action plans. This has allowed the formation of groups of land owners within each sub-basin for a ground-up planning/implementation process. This process lead to the development and funding ($3 million) of over 110 projects by the State of Oregon during 1994 and 1995.

- Washington Model Watersheds: The Washington MWS's vary in complexity, but generally have a low to moderate complexity factor. Asotin Creek has the smallest number of major land owners and they have all become major participants in the plan. Aquatic resource problems are severe, but potential for recovery is high. The Tucannon River has generally enjoyed wide participation from a majority of the land owners. The MWS process has reinforced this process with a greater technical understanding of the problems and participation in the solution design. Pataha Creek is the newest comer to watershed planning for anadromous fish. Although only the upper reaches are suitable for steelhead use, it is major tributary, and contributor of sediment to the lower Tucannon River. This watershed is enjoying a growing participation from the landowners. These Washington MWS's have had good participation from the U.S. Forest Service and from Washington State land managers. They have been the recipients of the technical expertise of a "Stream Team" sponsored by the NRCS from Spokan, Washington. This team has provided technical expertise to collect and analyze resource information, and write the watershed plans. The State of Washington has since given each watershed $180,000 for project implementation during 1996 and 1997.

- Idaho Model Watersheds: The Idaho Model Watersheds have generally been less complex for watershed plan development, with the exception of the Lemhi River. Before MWS planning, the Lemhi Irrigation District had aggressively participated in an irrigation diversion screening and consolidation program. The MWS process expanded the effort to include other resource management areas such as livestock grazing and maintenance/improvement of channel complexity. The Pahsimeroi watershed is generally less complex and has not had wide landowner participation, but several resources concerns are being addressed successfully. The East Fork Salmon River generally has the best quality habitat conditions, but grazing management concerns are being addressed by several landowners.

Bonneville Support to Model Watersheds: Past, Present and Future

A summary of the areas of support and their dollar amounts to each of the watersheds is shown in Table 2.

The level of continuing support to the MWS program depends upon the prioritization process established by the NPPC. Request from the MWS's for fiscal year 1997 include stable support for administration, with substantial increases requested for project implementation. All of the MWS plans will be completed by June, 1996 and are prepared to begin full implementation. It is estimated that a sustained habitat project funding level of $1,750,000/year for ten years is needed to fully implement the MWS plans. There are presently discussions within the region to designate a portion of BPA's fish and wildlife budget to the implementation of existing MWS plans and to expand the watershed program throughout the Columbia River Basin. The MWS program has proven to be an effective means to implement salmon habitat restoration on a watershed level. BPA will continue to support the MWS and future watershed program to implement salmon habitat improvement within the Columbia River Basin.

Note: This information is provided for reference purposes only. Although the information provided here was accurate and current when first created, it is now outdated.

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Grande Ronde Model Watershed Program "Partnership for Success"

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Project Background

With the imminent Endangered Species Act (ESA) listing of spring chinook salmon on the horizon, the Union County Commission and Wallowa Court determined that a grass-roots, locally based effort working to coordinate existing local, state, and federal programs could effectively maintain, enhance, and restore our watershed. Joining in this effort, the Northwest Power Planning Council selected the Grande Ronde basin as a model watershed for Oregon, and the Governor's office through the Strategic Water Management Group certified the program. Bonneville Power Administration provides the administrative funding.

Appointed in May 1992, the Grande Ronde Model Watershed Program Board of Directors (Board) represents a diverse group of interests with the common vision of a healthy watershed. Participants include stock-growers, farmers, tribes, environmentalists, elected officials, and public lands, community, forestry, and fish and wildlife representatives.

A watershed can be managed to:

- Maintain and enhance natural aquatic biological diversity.
- Enhance or protect threatened species populations.
- Maximize natural resource yields in wildlife, water, commodities, or human uses.
- Support the economic and social livelihood of a community.

With that understanding, the Board formulated a mission statement which incorporates many of these elements. It is to "develop and oversee the implementation, maintenance, and monitoring of coordinated resource management that will enhance the natural resources of the Grande Ronde basin." Although addressing multiple elements in watershed restoration is perhaps more difficult that pursuing a single purpose, the Board felt this approach essential.

The basin encompasses the Blue Mountain region of northeastern Oregon. It is approximately 13,689 km2 (5,265 mi2) in size and has 280 streams and rivers containing over 4,160 km (2,600 mi) of fisheries. Land ownership is approximately 65 percent public and 35 percent private. The basin supports numerous healthy populations of fish and wildlife, as well as the ESA-listed spring chinook salmon.

Initial Steps

An important first task was developing memorandums of understanding to create partnerships with local residents, state and federal agencies, tribes, and interest groups concerned with the management of the Grande Ronde watershed. From there, stream survey data available from state and federal agencies were compiled into a Habitat Assessment. This assessment was peer reviewed and accepted by the Board. This provided a sound "starting point" to develop a plan and focus restoration activities.

A technical committee was formed consisting of biologists, hydrologists, a soil scientist, forester, and other resource specialists to advise and provide recommendations to the Board on planning direction, technical issues, and to review and evaluate project proposals for technical merit and adequacy. Local agency staffs, the tribes, and private individuals with technical expertise are playing a crucial, key role in the model watershed process by serving on this committee. Reviewing project proposals has become one of the main functions of the technical committee, and is an effective means for ensuring cooperation and coordination among agencies and the various projects and activities in the basin.

Model Watershed Action Plan

Next the Grande Ronde Model Watershed Operations_Action Plan was prepared. It serves as a basin-wide framework to identify priority (for spring chinook salmon) subwatersheds for more detailed planning. It incorporates information gathered from several prior planning documents as well as the Habitat Assessment. The plan includes restoration criteria to aid in the process of prioritizing project actions. Staff is continuing to develop detailed subwatershed plans and project actions, working with landowner groups and others as appropriate. Landowner participation in this process is completely voluntary.

Additionally, the model watershed program initiated the Grande Ronde Ecosystem Diagnosis and Treatment (GREDT) study. This was undertaken to provide technical information to the Board and technical committee in their effort to plan and implement watershed restoration activities. The study was motivated by a need for a science-based methodology that promotes effectiveness and accountability. The analysis focuses on spring chinook salmon, which serves as a diagnostic species in assessing the condition of the watershed for sustainability of its resources and related societal values. This study assumes that humans and their values are integral parts of an ecosystem and that human communities within the Grande Ronde basin desire a healthy watershed_one that can sustain natural resources as well as economic and social values for future generations.

An effectiveness monitoring strategy has been developed and will be incorporated in each subwatershed plan. On-going monitoring efforts will be identified, coordinated, and used to establish gaps that need to be addressed. Each project action also contains a monitoring component. Several projects include monitoring by local high school students.

The Grande Ronde Model Watershed Program serves as an educational forum for landowner groups through coordination with the Oregon Cattlemen's Association and local Soil and Water Conservation Districts. Additionally, the model watershed program is defining for itself a role as facilitator of improved dialogue between local, state, tribes, and federal natural resource management agencies. The model is especially helpful in encouraging coordination on issues beyond normal jurisdictional boundaries, and creating cooperative and incentive-based ways to encourage private landowners to take part in restoration efforts.

Habitat Restoration Progress

In the past 14 months, the model watershed program has assisted in developing many project proposals for habitat restoration in the basin. These projects involve private landowners, schools, organizations, tribes, and local, state, and federal government agencies. Funding has been recommended and secured for approximately 111 worthy, well-designed projects. The scope of these projects address factors such as:

- Fish passage structures/irrigation diversion improvements.
- Riparian and rangeland livestock management/off-stream water development.
- Sediment.
- Erosion reduction.
- Water quality and quantity.
- Fish habitat.
- Technical seminars addressing riparian grazing.
- Education.

Implementation of these projects is in various stages, with 49 completed, 45 presently on-going, and others to start in the spring/summer 1996. Funding for these projects is available through private landowners, Oregon Watershed Health Program (state lottery funds), Bonneville Power Administration, Bureau of Reclamation, and other state and federal agency programs, as well as private groups and organizations.

Long-term project planning is ongoing, creating an advantage in securing and utilizing habitat restoration funds as opportunities arise. Project proposals in priority subwatersheds are developed with the objective to address identified environmental conditions such as fish passage problems, substandard riparian conditions (i.e., streambank erosion, streambed sedimentation, altered channel morphology, loss of pools, and reduced habitat complexity), upland conditions producing sediment, poor water quality, and depleted flow conditions.

In conclusion, the Grande Ronde Model Watershed Program is an exciting and innovative experiment in citizen-based natural resource planning by coordinating among all entities involved in watershed activities in the basin and is charged with providing a model for other watershed basins to consider.

Considerations

It takes time to create partnerships and develop a strong basin council. Being based in local county government has been very positive and offered additional opportunities. A watershed council must allow for a diverse group of interests, local agendas, and perspectives.

Planning is vital before moving to projects. The key is a local assessment of environmental conditions in order to establish priorities driven by the local governments, agencies, tribes, and community. The time expended for this is also well utilized in developing local consensus and unity.

Realize project development is very time consuming, and many local entities must be involved and incorporated in the process. Implementation is a multi-year process, recognizing our actions today will make a difference in the quality of our environment 25-50 years from now.

The availability of administrative and technical assistance/support to the watershed council is a crucial component.

Endangered Salmon, Turning Emotions Into Action

Ralph Swift, Model Watershed Project Coordinator
Idaho Soil Conservation Commission, Salmon, ID

Introduction

Idaho's Model Watershed Project began in November 1992 when former Governor of Idaho, Cecil Andrus, named the Idaho Soil Conservation Commission (SCC) as lead agency for this project. Model watersheds were an outcome of the Northwest Power Planning Council's Strategy for Salmon (NPPC, 1991). The SCC selected three watersheds to be included in the project: the Lemhi River, Pahsimeroi River, and East Fork of the Salmon River (Figure 1). These watersheds were chosen because they had similar land use, land ownership patterns, agricultural enterprises, and salmon habitat issues. Also, these three drainages contribute approximately 50 percent of the salmon produced in the Upper Salmon River drainage.

The SCC receives annual funding from Bonneville Power Administration (BPA) to operate the project. This funding is used for office space, staff, and administrative support. Neither the NPPC nor BPA gave the SCC specific directions regarding the project operations or the desired end product. The general directions were to assess what was known about the watersheds and then implement actions on the ground that would benefit salmon habitat.

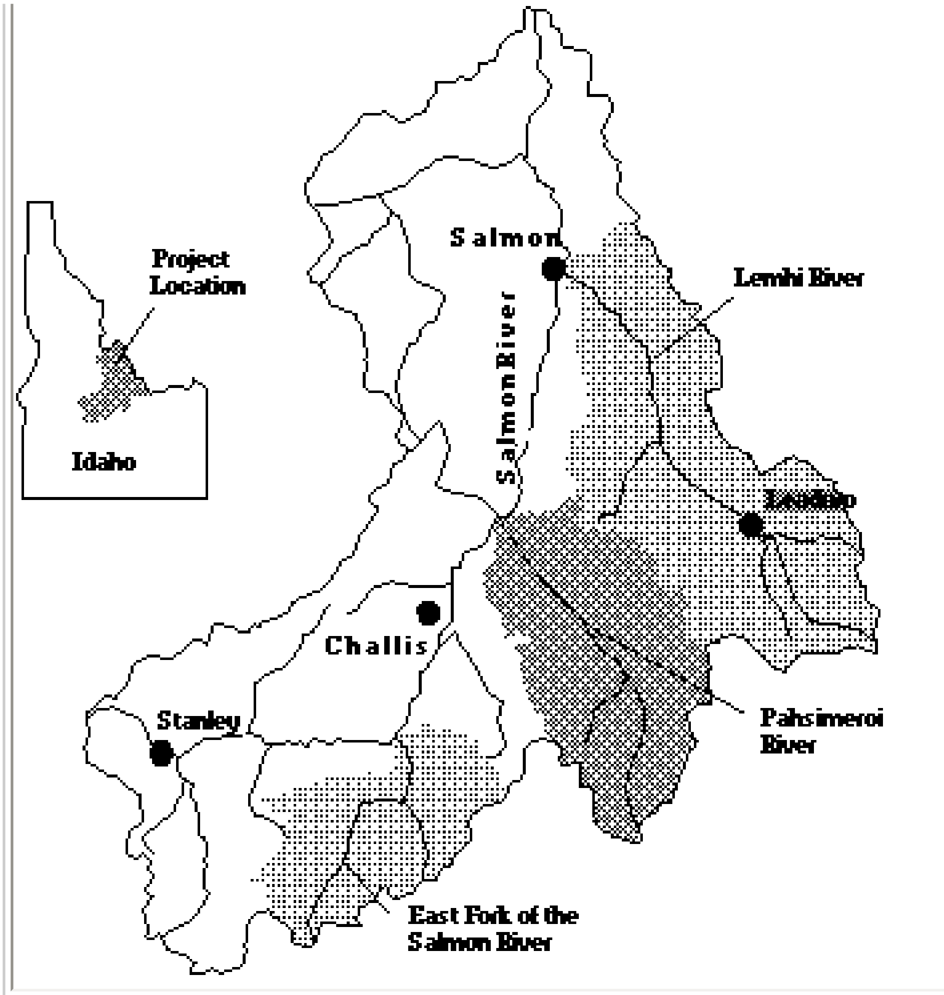

Figure 1. Model Watershed Project area.

The SCC designated two local soil and water conservation districts (Districts) to take the lead in developing the project. The SCC also hired a project coordinator and administrative staff to provide the necessary project support. The Districts held an organizational meeting and formed a local steering group consisting of mostly private landowners. These landowners then organized the advisory committee and requested assistance from agencies and the Shoshone-Bannock Tribes in the form of a technical advisory committee. The 15-member advisory committee represents a cross-section of landowners, federal land managers, conservation interests, and industry representatives. These committees have worked hand-in-hand to developed a vision statement, objective, and goals for the model watershed. They have also guided a dynamic planning process that has been effective in implementing projects to benefit fish and fish habitat, while developing a long-term plan to address some of the more controversial aspects of watershed enhancement.

Project Setting

The three watersheds have a drainage area of approximately 7,020 square kilometers (2,700 square miles). The region has a mixture of land ownership. Most of the valley bottoms are privately owned. The low foothills are sagebrush grazing land managed by the Bureau of Land Management (BLM). Land ownership is approximately 90 percent federal and 10 percent private. The reverse is true when you talk about existing occupied salmon habitat (i.e., 90 percent is privately owned and 10 percent is federally managed). The area has a semi-desert climate with an average annual precipitation of 23 centimeters (9 inches) in the valley with about 60 centimeters (24 inches) in the mountains. Snow pack is a key to stream flow each year. No appreciable water storage systems exist in any of the three basins except what is stored in the underground aquifers.

Beef cattle are the number one agriculture product, with about 25,000 cows present in the three watersheds. Some small dairies exist near Salmon. Lamb production has dropped from an annual high of 50,000 animals in the 1960s to only 2,000 today. Most sheep grazing allotments have been converted to allotments for cattle. Hay is the primary crop and all croplands are flood or sprinkler irrigated. The hay is used to support the cattle during the winter months; none is marketed outside the valleys. Public grazing allotments support about 80 percent of the cattle from May until mid-October.

The wood products industry is active in the area, but only a small amount of logging takes place in the three watersheds. Past mining activity such as dredging, hydraulic, and underground mining is evident throughout all three drainages. Most of this mining activity occurred in the side drainages where its effect on anadromous fish habitat was limited. For the most part, this mining activity occurred before the turn of the century and the effects have become minimized over time.

Recreation now plays a large role in the local economies of Salmon and Challis. It accounts for about 25 percent of the income in the Salmon community. The loss of the salmon fishery has had a significant adverse economic impact on these communities. It is estimated that this loss has been $2 million dollars per year (Idaho Soil Conservation Commission, 1996). This, coupled with the cultural and subsistence loss by the tribes, makes the need to do something a high priority.

Watershed Assessment

Watershed assessments were conducted for each drainage to identify factors limiting salmon production. Biologists conducted drainage-by-drainage assessments analyzing the salmon's historic and current watershed use. Habitat inventories were then conducted in the stream segments that currently support salmon production. These inventories were conducted by inter-agency crews led by BLM fish biologists. The inventories collected data on the quantity and quality of pools, riffles, and runs. An assessment of streambank stability and quality of riparian cover was also made. Assessments conducted by other agencies, as well as previous studies on fish habitat conditions were also reviewed.

Problems identified by the watershed assessments and habitat inventories include:

- Streambank stability.
- Delayed migration of juveniles through irrigation diversions.
- Blockage of upstream migration by irrigation withdrawals or diversions.
- Livestock or vehicles crossing streams creating sediment.

- Poor control of irrigation water delivery.
- High summer water temperatures with large diurnal deviations.
- Sedimentation of spawning gravels.
- Lack of rearing and resting pools.
- Insufficient overhanging bank cover.

Model Watershed Goal Setting

The advisory committee established the following watershed goals:

- Provide for the safe and timely passage of migrating fish through critical watershed reaches.
- Protect and enhance in-stream and riparian environments to maximize fish production and escapement.
- Ensure than any resources invested achieve maximum return for multiple-use benefits.
- Develop or adapt a holistic watershed management approach for fish habitat maintenance, enhancement, and restoration.

The technical team, using the goals established by the advisory committee and the habitat inventory, developed five overall goals for evaluating the individual watersheds and stream segments. A biologist team then made subjective assessments for each stream segment and assigned a priority rating of high, medium, or low for that goal. Using a criterion of the next available dollar, the final priorities for the project area were established as shown in Table 1.

Table 1. Habitat goals and priorities between the Model Watershed Project areas.

Goals	Lemhi River Watershed					Pahsimeroi River Watershed		East Fork of the Salmon River Watershed		
	River Mouth to Agency Creek	Agency Creek to Hayden Creek	Hayden Creek to Leadore	Big Springs Creek	Hayden Creek	River Mouth to Hooper Lane	Patterson-Big Springs Creek	River Mouth to Herd Creek	Herd Creek to Germania Creek	Herd Creek
Increase in-stream flows during critical fish migration periods	● [1]	○	○	○	◍	●	○	○	○	○
Reduce the number of physical barriers hindering fish migrations	◍	○	○	○	◍	●	○	○	○	○
Develop new rearing and resting pools	○	○	○	○	○	○	○	○	○	○
Establish riparian vegetation along critical areas to provide cover and reduce temps	○	○	●	●	○	●	◍	○	○	●
Reduce the sediment levels within spawning gravels	○	○	◍	◍	○	○	◍	○	○	◍

● Highest priority

◍ Medium priority

○ Low priority until other problems are solved

Footnote

1 This priority is currently being addressed by the Bureau of Reclamation in cooperation with the Lemhi Water Users under the Lemhi Model Water Conservation Project.

Action Development

Actions to address the goals were developed jointly by the advisory and technical committees. It must be noted that joint development does not mean joint overall support for all actions. For example, while the committees may have had a consensus on a goal, the action and time frame in which to reach the goal were not always agreed upon. The actions identified in the Model Watershed Plan can be grouped into the following general categories:

- Stream flow and flow augmentation.
- Diversion and fish screen management.

- Fish habitat restoration.

- Fish habitat maintenance and enhancement.

  The following are examples of actions that correspond with the above general categories:

- Use irrigation water conservation or small, water-storage facilities to augment stream flow during low-flow periods.

- Combine or eliminate some irrigation diversions, or use alternatives to diversions such as an irrigation well.

- Establish pool habitat using enhancement structures or allowing natural processes to meander previously straightened stream segments. Provide continual flows for periods of time to allow fish migration past dewatered sections of streams.

- Maintain, improve or re-establish riparian cover along streambanks through use of pasture management systems or by limiting livestock access to some riparian communities during some or all of the year.

Implementing Action

The majority of actions proposed are tied to private landowners willing to make a voluntary decision to implement some change in the way they currently conduct business. Using a cooperative, collaborative, interagency approach in working with landowners, irrigators, and cattle grazers works the best. Small steering groups were assigned to work on the larger actions, such as managing streams flows. Interdisciplinary teams were put together that had the technical expertise to access the situation and recommend alternatives. Landowners, Soil Conservation District Supervisors, and irrigation district representatives would then discuss the alternatives and set a course of direction. This approach leads to solutions being proposed that have a chance to be supported by the decision makers.

Funding Action

Funding for action start-up costs has come from many different sources. BPA has funded several projects. Idaho Fish and Game has funded projects through the Challenge Grant and their Habitat Improvement Program. The Shoshone-Bannock Tribes has supplied manpower using their Salmon Corp team. The Bureau of Reclamation has funding authority to develop a water management demonstration project in the Lemhi Basin and is also helping fund a River Basin Study with the Natural Resources Conservation Service (NRCS) and BPA. The NRCS and the Idaho Fish and Game have supported staff for engineering and technical assistance. The SCC has funded the Lemhi Soil and Water Conservation District to do a collaborative water quality study with the Bureau of Reclamation.

Evidence of Project Success

The dynamic nature of the Model Watershed Project has led to a number of actions, such as:

- Lemhi Irrigation District implementing a water management plan to reduce the conflicts between water withdrawal for irrigation and anadromous fish migration.
- Innovative ways to treat streambank erosion and protect fish habitat.
- Pasture management systems to maintain and enhance 8 kilometers (5 miles) of primary fish habitat in the Pahsimeroi and Lemhi watersheds.
- Reconnecting 11 kilometers (7 miles) of habitat using a water transfer from the Pahsimeroi River to the Salmon River.

Summary and Conclusions

The Model Watershed Project has been locally led and locally supported. It is directed by an advisory committee represented by the key players and interests in the watersheds. The Advisory Committee and Technical Committees work closely with the project coordinator to review and recommend actions to meet the goals and proceed toward the vision. This process has been successful in completing a plan and implementing actions that will improve the watershed's overall ability to sustain production of goods and services, as well as the many other values that watershed ecosystems can provide.

References

NPPC. (1991) Amendments to the Columbia River Basin Fish and Wildlife Program (Phase One). Northwest Power Planning Council Document 91-27.

Idaho Soil Conservation Commission. (1996) Model Watershed Plan for the Lemhi, Pahsimeroi and East Fork of the Salmon River.

Pataha Creek, Its Changing Ways

Duane Bartels, Model Watershed Project Coordinator
Pomeroy Conservation District, Pomeroy, WA

Pataha Creek has undergone a tremendous change over the last century. Named "Pataha" by the Indians, the creek today bears little resemblance to its meaning of "Brushy Creek." Located in southeast Washington State, it meanders through the southern half of Garfield County from its beginning in the Umatilla National Forest to its end where it flows into the Tucannon River in northeast Columbia County.

There was a time, in recent history, when a person had to literally crawl on hands and knees to reach the edge of Pataha Creek. Today one can walk to the edge and peer into the channel with few obstructions to block the view. Over a relatively short period of time, natural events coupled with man's activities, have changed Pataha Creek from a pristine fish and wildlife haven to an incised channel used largely for the transportation of silt and other contaminants.

What happened to the camouflage cover that once bordered the creek cannot be traced to one particular source. Years of farming and grazing next to the creek can be blamed for part of the degradation. Natural events, such as a quick snow melt in the mountains and the resulting high water, have removed much of the natural vegetation that bordered the creek. Today most of the 80-kilometer (50-mile) stretch of the Pataha has very little vegetation to protect its streambanks and provide cover and shade. This loss makes it virtually impossible to maintain lower water temperatures and fish habitat.

Coupled with its own demise, Pataha Creek has had an influence on other rivers. Draining into the Tucannon River, it has deposited silt and warmer water into chinook salmon habitat. With the lower portion of the Pataha once a rearing area for young salmon hatched in the Tucannon River, the Pataha now creates a barrier for adults entering the lower Tucannon to migrate further up its waters to spawn. Although not the entire problem for reduction of salmon in the Tucannon River, the Pataha has lost its past history of supplementing and aiding the Tucannon in its salmon production.

From a determination by the Northwest Power Planning Council in 1993, the Pataha Creek Watershed was included with the Tucannon and Asotin watersheds as model watersheds to develop a plan to restore habitat for the endangered Snake River salmon. A coordinated resource management system process had started. Two committees consisting of landowners and technical personnel were formed to begin the process of writing a watershed plan to restore fish habitat. The purpose of the technical committee is to provide expertise with the existing problems and their proposed solutions. The purpose of the landowner steering committee is to provide the local input regarding the feasibility and economical aspects of the solutions to the problems. The resulting watershed plan includes a compromised solution from the different groups that are involved in writing the watershed plan.

While in the process of writing the watershed plan, funding for demonstration projects was provided by the Bonneville Power Administration. Sites were selected to demonstrate proposed solutions to the problems identified by the technical committee. Also during this period, implementation funding for the plan was obtained by the Washington State Conservation Commission. Due to the uniqueness of these three model watersheds, some variations in the cost-share portion of the grant policies were requested by the watersheds and were granted by the Conservation Commission.

Implementation is now underway. Cost-sharing is being used for in-stream and riparian practices, along with extensive upland practices being implemented on private and state-owned cropland and rangeland. Some of the many in-stream and riparian practices include log weirs, bioengineered bank stabilization using tree, shrub and grass plantings, and in some cases, concrete or rock structures. Other practices include the installation of fish ladders to overcome fish barriers, riparian fencing to manage cattle along the stream corridor, and off-site watering facilities to reduce direct livestock impacts on the streambanks and water quality. Some of the upland practices include additional installation of terraces, waterways, and desilting basins. No-till seeding will be cost-shared to demonstrate its impact on soil erosion and the economics of no-till farming in comparison to conventional tillage.

To document the effect of these Best Management Practices (BMPs) on the amount of sediment entering the Pataha Creek, an extensive monitoring program has been implemented. Along with written documentation of before and after projected effects of practice installation, the direct sediment and other element measurements are being extracted from the Pataha Creek. This is occurring hourly using water samplers that are placed in strategic locations. This information, which is being cross referenced with flow readings that are downloaded into computers daily, will determine the actual delivery of sediment and other elements by the stream into the lower portion of Pataha Creek and the Tucannon River.

The final project goal will be to determine whether the increased and intensive installation of Best Management Practices in and along the stream, coupled with BMPs on upland areas, will restore the habitat in the Pataha Creek and influence sediment delivery to the Tucannon River. If habitat can be restored to a level that will influence the number of salmon entering the Tucannon River to spawn and rear, then the Pataha has accomplished its goal. In the process of completing this #1 goal, it will have restored the habitat within the Pataha Creek Watershed to the point where it can maintain a trout and steelhead fishery of its own.

Above and beyond the numerous fish and wildlife benefits, there are also benefits for the landowners and others who live within the Pataha Creek Model Watershed. Whether it takes the salmon to move this process along or not, it will be the cooperative effort of many people and agencies to put a program together that benefits everyone. Knowing that this type of project can be accomplished without government regulation, and that it is a voluntary effort of you and me, says it all. The Pataha Creek Watershed can once again be brought back in the direction that it once was, and may someday again be referred to as the "Brushy Creek."

Accepting Challenges to Develop a Model Watershed Plan for the Tucannon River

Art Sunderland, Project Coordinator
Columbia Conservation District, Dayton, WA

Location

The Tucannon River is located in northeastern Columbia County, western Garfield County, and in southeastern Washington State. You will enjoy starting at its headwaters, which are located in the Wenaha-Tucannon Wilderness Area in the Blue Mountains. The river flows rapidly through the steep, rugged canyons with a beautiful forest landscape of pine and fir. It enters another open site of steep canyons with rangeland, then into more steep canyons with high producing wheatland along the top. The river's final destination is the Snake River. The elevation ranges from 1,920 meters (6,400 feet) in the Blue Mountains to 150 meters (500 feet) at the mouth of the river. You'll find the temperature will go from -25oF in the winter to around 100oF in the summer. The rainfall varies from 20 centimeters (8 inches) in the lower elevations to 175 centimeters (70 inches) in the higher elevations. The area has deeded rights for fishing etc. for several Indian tribes.

The area was first settled in the 1850s and many small farms dotted the Tucannon River Valley. Today there are 93 farms, ranging from 2 hectares (5 acres) to over 2,000 hectares (5,000 acres) in size. There are approximately 93 families with a population of 825 people in the county and 251 people in the town of Starbuck. This population occupies two-thirds of the 84,123 hectares (210,307 acres) of land in the watershed.

Most of the land within the watershed is privately owned (Table 1). The landowners are proud of the river and are always looking for ways to improve the habitat and yet stay economically sound.

The floods of 1964-1965 and a smaller one in the 1970s have caused most of the degradation of shade along the river. These floods also brought about many changes in the river itself. These changes pose many problems for future habitat restoration.

Table 1. Land use and ownership within the Tucannon River Watershed.

Land Use	Hectares	acres
Dry Cropland	27,172	67,930
Irrigated Cropland	1,029	2,573
HEL Cropland	24,400	61,000
Forestland	21,867	54,667
Rangeland	32,898	82,244
Pasture and Hayland	1,134	2,835
Land Ownership	Percentage	
Private	71%	
State	6%	
Federal	23%	

Now, let's look at the challenges that the landowners, the Columbia Conservation District (District), and the agency representatives have been working on.

Challenge No. I

During 1983 and 1984, the District, Duane Scott of the Soil Conservation Service (SCS), two fish biologists, and landowners felt there was a need for fish habitat and streambank protection work. These same people, working together, walked the Tucannon River area from Highway 12 to State Game Ranges, which covered approximately 24 kilometers (15 miles). Areas for possible demonstration sites were pinpointed. The next project was to find suitable funding for putting these practices into viable demonstrations. No funding sources could be found at that time.

Challenge No. II

During 1984 and 1985, Dusty Eddy of the Soil Conservation office, the District, the fish biologists from Washington State Department of Fish and Wildlife, and the landowners, at a small neighborhood planning session, decided Challenge No. I was too good not to see it carried out and enlarged. Water quality would be the additional emphasis.

Project funding was sought from the Bonneville Power Administration (BPA) and the Northwest Power Planning Council (NPPC). It, again, was a disappointment when we were told that there were no funds available for these practices.

Challenge No. III

Using what plans all of us had developed from 1983 through 1985, we sought funding from the Washington State Department of Ecology (WDOE). "Water Quality" scheduled a hearing with WDOE. It was our job, as cooperators, to educate our new-found listener that nonpoint practices were just as important as point practices; and, if water quality was to be improved, our practices needed to be applied to the cropland and rangeland adjoining the Tucannon River. With WDOE, we were directed toward a

Referendum 39 grant from the Clean Water Act.

At last, we were underway. All interested agency people and landowners met and selected practices of strip-cropping, divided slopes, and limited tillage or no-till for the nonpoint area. As we planned for the nonpoint, we were reminded by the landowners that we will never stop all of the erosion that runs into the river. With this in mind, 12 sites were observed for desilting basins. Two basins were selected to be constructed in 1987 (Table 2). Howard Basin had 492 hectares (1,230 acres) of rangeland and 720 hectares (1,800 acres) of cropland. Hovland Basin had 480 hectares (1,200 acres) of rangeland and 440 hectares (1,100 acres) of cropland. These basins proved to be of great value, because we had captured large volumes of runoff. To monitor these basins and runoffs, we obtained a list of all pesticides that had been applied during the past three years in the two drainages. Tests were run at the SCS Western Technical Center. To everyone's surprise, the test results showed no measurable amounts of pesticide were going into the river.

Keep in mind frozen ground, chinook winds, and excess rain play an important part in these studies. Frost tubes and rain gauges are located in the upper nonpoint cropland with readings made daily.

Table 2. Silt trapped in each basin.

	Howard Basin		Hovland Basin	
Year	Silt Trapped (metric tons)	Silt Trapped (tons)	Silt Trapped (metrics tons)	Silt Trapped (tons)
1988	2,138	2,375	1,436	1,596
1989	1,373	1,525	1,138	1,264
1990	568	631	0	0
1991	67	74	0	0
1992	0	0	0	0
1993	540	600	45	50
1994	0	0	0	0

Along with the nonpoint practices and basins, we asked for land along the river that had been severely damaged by the flood. A landowner allowed us to plant 11,500 cottonwoods and willow whips, along with 250 pine trees, and establish 2.4 kilometers (1.5 miles) of fence along the riparian zone for streambank protection. The plant survival after beaver control was 15 percent. Following these practices, we wanted to develop pools in the river for fish habitat enhancement. The Washington Department of Fisheries, U.S. Forest Service, and a landowner cooperator spanned two large log weirs across the river with riprap on each side. These were well received. Our last practice to demonstrate was streambank protection and cattle management for water and calving by using water gaps and fencing. There were 54 structures of various methods installed. The greatest success was with heavy rock deflectors, which were cabled together using a drill, epoxy glue, and airplane cable. These water quality improvement demonstrations pointed us to a need for greater expansion and a broad plan.

Challenge No. IV

In 1991, the District asked the Soil Conservation Service to place the Tucannon River into a Watershed

Plan and fund it under PL-566. The plan, unfortunately, was tied very closely to the Food Security Act of the 1985 Farm Program. Because of this tie, the practice designed to help improve water quality was not acceptable by the landowners. The landowners felt there was too much regulation. This points to the need for an on-the-ground approach with landowners. To have better cooperation and less regulation will show more true results on the land. PL-566 is not dead, and it is our hope to use it in the next challenge, if possible.

Challenge No. V

Yes, this challenge is just more of the same. This time, in 1993, the Northwest Power Planning Council and Bonneville Power Administration challenged the District to develop a Model Watershed Plan. The coordinated resource planning process that was used in all previous challenges is being put into this new challenge. This plan will include the entire watershed, going from the headwaters to the mouth. It includes the forestland, rangeland, and cropland, with the big push for habitat improvement on the river. Of the "four H's" that the NPPC has in its strategic plan (i.e., harvest, hydropower, habitat, hatcheries), the Tucannon River has the big "H" habitat, which stands for protection and restoration of habitat.

The Columbia Conservation District and its landowners had already set the stage for the plan. They had identified problems such as high water temperatures, sediment, streambank protection, nonpoint erosion, and a need for riparian management where economically sound. Resource management planning is great, but the key is cooperation by all agencies. Thirteen different groups have been involved in Challenges I through IV. Many of you are familiar with the sayings of Will Rogers. The one that fits us best is "You may be on the right track, but if you don't move you'll get run over."

This latest challenge is our notice for moving. The stage is set. We have an excellent Landowner Steering Committee. They have plenty of experience dealing with the watershed. The technical committee has been working hard, and trust and cooperation is showing up everywhere. The first draft is completed and ratified, and will be ready for the second draft by the time this conference is over. The plan is flexible, shows leadership, and if funded, will be workable. This plan will work because it is built around thinking from all people concerned and is not built around regulations.

If the plan is funded, the Columbia Conservation District and the agency representatives putting it together will meet with the landowners in small groups in their homes to discuss what the plan means to them and their property. If they still want changes, we will be flexible to these needs. Trust, cooperation, flexibility, and desire will make this Model Watershed Plan for the Tucannon River work.

One of the great authors, Margaret Mead, made a statement that I think sums up the work of our Landowner Steering Committee and Technical Work Committee: "Never doubt that a small group of thoughtful, committed citizens can change the world, indeed, it is the only thing that has."

Should you wish a copy of our final plan, please write me.

Building Partnerships-A Case Study of the Umatilla River Watershed

Ann Beier, Senior Planner
Umatilla County
Pendleton, OR

Luise Langheinrich, Coordinator
Umatilla Basin Watershed Council
Pendleton, OR

Overview of the Umatilla River Watershed

The Umatilla River watershed is located in northeastern Oregon (Figure 1). The Umatilla originates in the Blue Mountains and flows northeasterly into the Columbia. Prior to settlement, native grasses covered the Umatilla plateau above the Columbia River and the Blue Mountains were covered with open groves of Ponderosa Pine, Western Larch, Engelmann Spruce, and Douglas Fir. Indians hunted and fished in the region and thousands of anadromous fish, including spring and fall Chinook, and steelhead fought their way up the Umatilla to spawn.

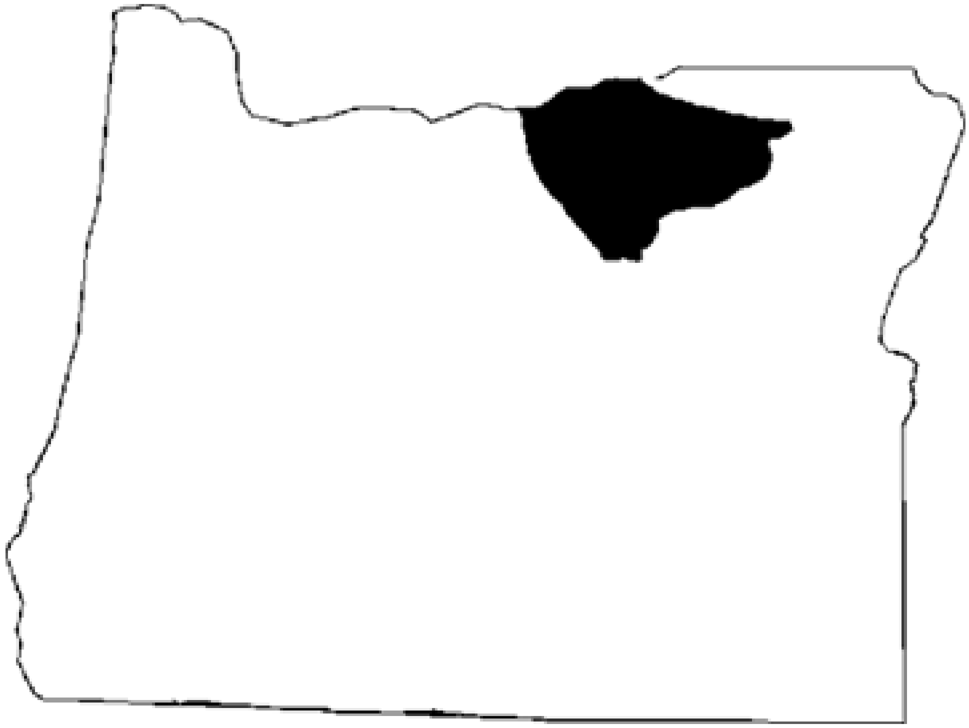

Figure 1. Umatella Basin Watershed

The Oregon Trail opened up the west and settlement in the mid-1800s. With settlement came increased agrarian land use. Intensified management practices changed the nature of the watershed. Over-grazing resulted in native grasses giving way to sagebrush. Wheat farming on steep slopes increases erosion of the areas' fertile loess soils. Irrigation of alfalfa, potatoes and other vegetables in the western part of the basin placed demands on Umatilla River water and ground water. Irrigation diversion dams blocked upstream salmon passage resulting in the extinction of native salmon runs and declines in other anadromous fish populations.

Much of the upper portion of the Umatilla watershed flows through range and forest land. Some of the watershed is owned and managed by the Confederated Tribes of the Umatilla Indian Reservation - the Umatilla, Cayuse, and Walla Walla tribes. Currently, approximately 40 percent of the watershed's acreage is range and 13 percent is forested. The central part of the watershed contains some of the most productive agricultural land in Oregon. Thirty percent of the watershed's acreage is in wheat, barley, canola, and other dry land crops. Irrigated crops are grown in the dryer west-end of the watershed and account for about 11 percent of total acreage. The watershed also faces increased population and the problems associated with urbanization.

Cultural practices have resulted in water quality problems such as excessive sedimentation, temperature standard exceedances and high ground-water nitrate concentrations. The Oregon Department of Environmental Quality (DEQ) recently issued its draft 1994/1996 List of Water Quality Limited Water Bodies, as required by section 303(d) of the Clean Water Act. According to the report, much of the mainstem Umatilla River and many of its tributaries are water quality limited. Some of the problems include seasonal violations of temperature, algae, and nutrient standards. In addition, there are violations associated with flow modifications and annual exceedances of fecal coliform and pH standards. In the western end of the Umatilla River watershed, ground water concerns prevail. An on-going DEQ study of ground water quality in that area found that 30 percent of wells tested exceeded the U.S. Environmental Protection Agency's (EPA) maximum contaminant level for nitrates (10 mg/l).

Despite these environmental problems, there is a strong foundation of cooperation and partnership in the Umatilla River Watershed. In the late 1980s, with increasing conflicts between irrigation and fisheries needs, representatives of the Bureau of Reclamation, the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) and local irrigation districts came up with a proposal to restore the watershed's fisheries while protecting irrigation uses. The group solicited federal funds for the Lower Umatilla Basin project, a water transfer project. This project diverts water from the Columbia River, and stores it in an off-stream reservoir for summer release to meet irrigation needs. This water substitutes for Umatilla River water retained instream for fisheries. This effort, in conjunction with hatchery development projects co-sponsored by the Bonneville Power Administration, CTUIR, and the Oregon Department of Fish and Wildlife (ODFW) has been a success. Salmon have returned to the Umatilla River for the first time in over seventy years.

The Umatilla Basin Watershed Council-New Partnerships and New Issues

In 1994, the Oregon legislature passed House Bill 2215, encouraging the creation of local watershed councils. This bill was amended in 1995 (HB 3441) and provides on-going authority and funding for watershed councils. Oregon is one of the few states providing such support for watershed councils.

The Umatilla Basin Watershed Council (the Council) was formed in May, 1994 with a goal of coordinating efforts for enhancing the health of the Umatilla River watershed. In forming the Council, local residents expressed concern that water resource management in the watershed was inefficient due to the numerous federal, state and local agencies involved. For example, the U.S. Forest Service manages the land surrounding the headwaters of the Umatilla River. A portion of the watershed is owned by the CTUIR. A number of irrigation districts and the U.S. Bureau of Reclamation manage water uses in the western end of the basin. Numerous other agencies participate in managing the natural resources of the Umatilla River watershed. Thus, a primary role of the Council is to form partnerships with these agencies and to help facilitate cooperation with individuals living in the watershed.

When the Council was originally formed, a major effort was made to represent all interests in the watershed and to ensure that all stakeholders would be involved and represented. The Council membership reflects this strategy. The Council is composed of fifteen local representatives with diverse backgrounds and interests including ranchers, farmers from both irrigated and dryland areas, local attorneys, business owners, a forestry consultant, tribal representatives and other watershed residents. Council members also represent different geographic areas in the watershed. In addition the Council is supported by technical experts from the area resource management agencies including DEQ, ODFW, Oregon Water Resources Department (OWRD), U.S. Forest Service and the Umatilla County Soil and Water Conservation District (SWCD) Council meetings are open to the public and all interested parties are invited to attend and participate.

Partnerships Offer Council Support

The Umatilla Basin Watershed Council benefits from a number of partnerships. First, the Council receives administrative support from EPA. Funds have been available for two years under section 104(b)(3) of the Clean Water Act. The Council is also supported by the Umatilla County Board of Commissioners. The value of support from local elected officials cannot be understated. First, such support provides increased credibility and validity to the organization. County financial support further validates the Council. County assistance goes beyond support for the Council itself to include funding for Council supported projects. For example, the County provided $8,500 seed money for a bioengineering project using video lottery funds. This funding was used by ODFW and the Umatilla County SWCD to leverage over $70,000 from other agencies and businesses for project construction and implementation.

The Council also benefits from other organizational partnerships. The Council and Umatilla County have entered into a Memorandum of Understanding with the local Natural Resource Conservation Service office and SWCD. Under the agreement, NRCS and SWCD provide office space and other administrative support. The Council benefits financially and from the linkage to the watershed's agricultural community.

Partnerships and Coordinating Efforts

One of the key responsibilities of the council and the Watershed Coordinator has been to understand the activities of the other agencies and to monitor projects in the Umatilla watershed. Agency representatives attend all Council meetings and provide information to the landowners represented on the Council. Natural resource agencies meet monthly to exchange information. The "Natural Resource Discussion Group" includes representatives of federal, tribal, state and local government. Members of nonprofit groups and the press sometimes sit in. These meetings are used to "compare notes" and most importantly to brainstorm better ways to serve the public and protect the region's resources. The group has compiled a directory of agencies and responsibilities so residents know who to call on particular issues. Several members of the group, including the Council, co-sponsored an Ecosystem Forum for landowners. The workshop was designed to promote ecosystem management and provide tools for individuals to enhance their own properties while contributing to the overall health of the watershed. Several agencies chipped in to fund an overflight and video of one of the Umatilla's main tributaries, Wildhorse Creek. Infrared photos taken on this flight identified areas with limited riparian vegetation and significant variations in stream temperature. These films are currently being used to educate both resource agencies and landowners. The agencies, and the Council, have also jointly funded several in-stream restoration actions.

The Umatilla Basin Watershed Council brings a new dimension to these partnerships by involving area residents. For example, Birch Creek is a major tributary to the Umatilla River and provides critical steelhead spawning habitat. Headwaters for Birch Creek are in the Umatilla National Forest and the stream flows through agricultural land before joining the Umatilla River. Recent forestry activities, increased agricultural production adjacent to the stream channel; removal of riparian vegetation and high flow events in the last few years have resulted in significant flood damage. These floods have eroded stream banks and encroached upon agricultural activities. The Council is currently working with land owners along Birch Creek and is facilitating discussions with agency experts to help them better understand the dynamics of their watershed. A goal of this project is to help landowners protect their properties while restoring watershed health. The value of bioengineering techniques for stream stabilization is a main focus of this discussion.

The Council is currently entering into a unique partnership with the Oregon DEQ and the CTUIR. As described earlier, the most recent draft section 303(d) list reports that the Umatilla River is water quality limited in a number of segments. The DEQ places a high priority on establishing a Total Maximum Daily Load (TMDL) for major pollutants in the Umatilla River. Many of the water quality problems appear to be linked to diffuse sources and the DEQ is taking a slightly different approach in developing the Umatilla River TMDL. The DEQ has solicited the assistance of CTUIR and the Watershed Council to work together to first determine monitoring needs and then to develop a management plan for the Umatilla River. This highly innovative approach will provide local residents with early input to the process and a voice in developing management options.

Public education remains a key to building partnerships. The Council has worked with the local media to promote watershed health. Council members and the watershed coordinator have appeared on local radio programs describing the Council's mission and activities. Local newspapers are very supportive and run regular articles on the Council's projects. The Council is currently sponsoring a watershed logo design contest for local schools. As part of this effort, Council members and agency representatives have volunteered to discuss watershed health in area classrooms.

The Value of Partnerships

Forming strong partnerships guarantees benefits for all involved. Partnerships result in a coordinated response. They allow partners to bring their unique expertise and experience to the table. The Council benefits from the experience of local residents coupled with the expertise of agency technical experts.

Partnerships allow leveraging of funds. Maintaining a $1,000 monitoring station may be impossible for one agency. However, a $1,000 project is manageable if five agencies each contribute $200. A $50,000 instream restoration project may be unimaginable for an individual landowner or agency. Using landowner's labor and equipment contribution to match funds provided by several agencies may be attainable. The project is stronger because of the buy-in and support of the many partners.

Finally, partners help when it comes to "begging" for money. It's no secret to those of you involved in watershed protection and restoration that funds for such efforts are limited, particularly with federal and state government cutbacks. Private foundations are a good source of funds, but there is increased competition for these dollars too. No matter who you ask for financial support, potential funding sources respond to projects that reflect strong partnerships and support from a number of entities.

Summary

The Umatilla Basin Watershed Council faces a number of challenges in working to restore health in the Umatilla River watershed. Both water quality and quantity concerns necessitate a coordinated and creative response. The Council has benefited from partnerships in the past and will continue to work to establish new partnerships. Partnerships provide enhanced funding opportunities, provide additional technical expertise, enhance credibility and promote involvement of all interested and effected parties.

Enabling Interdisciplinary Analysis

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New requirements for evaluating environmental conditions in the Pacific Northwest have led to increased demands for interdisciplinary analysis of complex environmental problems. Procedures for watershed analysis have been developed for use on public and private lands in Washington State (Washington Forest Practices Board 1993) and for federal lands in the Pacific Northwest (REO 1995). In both cases, analyses are intended to provide integrated, interdisciplinary evaluations of the biological, physical, and socio-economic interactions that influence the ecoscape and to describe environmental changes and their causes. "Interdisciplinary" implies that expertise from multiple disciplines is providing an integrated attack on a problem area. "Interdisciplinary" is carefully distinguished from "multi-disciplinary," which implies only that multiple inquiries are being carried out at the same time or in the same place.

Those developing the federal and state procedures called for integrated interdisciplinary evaluations for several reasons. First, environmental problems are inherently interdisciplinary. It is not possible to evaluate the reasons for a change in flood frequencies in an area, for example, without understanding the changes in land-use activities in the area, the processes that generate storm flow, the changes in channel morphology that have occurred, and the effects of vegetation change on both hydrology and geomorphology. One discipline, acting alone, would be equipped to evaluate only one aspect of the many that are likely to have influenced flooding. The influences that a single discipline would most likely overlook are indirect effects that involve the interaction of several components of the ecoscape. These influences appear to be subtle because they have fallen through the cracks between disciplines in the past. But as the least well understood, these influences are in most need of evaluation.

In addition, much disciplinocentric information already exists for many areas, yet the relevance of the information has not been recognized either because people have not had the time or inclination to look at the data or because the wrong people have examined it. Interdisciplinary work makes the undiscovered treasures of one field accessible to others who can recognize their value. In one case, for example, differences between a soils map and a vegetation map were thought to be errors until anthropological information revealed that the discrepancies recorded a profound change in vegetation type following the cessation of burning by Native Americans.

Interdisciplinary work is also needed to ensure that the overall focus of the project is maintained. Mono-disciplinary analyses filter the objectives through the biases of a single field. Interdisciplinary work helps ensure that the effort is apportioned according to the relevance of different types of information for addressing the overall needs, and not simply on the basis of how things are done in a particular field. An interdisciplinary evaluation continually challenges participants to show the relevance of their own pursuits to the overall objectives of the project.

Evaluation of the complex environmental problems dealt with during watershed analysis requires each specialist to have an appreciation for, interest in, and understanding of the other specialties represented in the effort. A major challenge for analysis teams is thus to find ways to promote interdisciplinary teamwork. Observations of federal watershed analysis teams, interviews with team members, and review of analysis documents indicate that this challenge is not yet being met effectively.

Barriers to Interdisciplinary Cooperation

One of the most severe hurdles for such analyses is the difficulty that individuals find in working together in an interdisciplinary framework. Many "teams" are teams in name only; individuals have done "their" parts of the analysis independently and have left the integration to an editor or have entirely ignored integration, electing instead to present the report as a series of stand-alone monodisciplinary chapters. In other cases, published analyses read as data compendia. Few of the reports provide the balanced, interdisciplinary perspective intended by the guiding directives. The reasons for the difficulty in achieving true interdisciplinary analysis are many and span the range between societal expectations and individuals' personalities.

At a societal scale, the philosophy of western science extols the value of increasingly detailed understanding within increasingly specialized sub-disciplines, while demeaning the value of the "generalist." Western science views the world largely as mechanistic: take a complicated thing apart and understand in detail how all the components work, then put them back together and you will understand the whole. This strategy for problem-solving permeates western education; the focus is on detail and precision rather than on meaning. Just as a standard grammarian cannot tell you the meaning of the sentence "He's bad," a standard biologist cannot tell you the meaning of a local decrease in salmon populations. But both can parse their respective sentences and find professional fulfillment in the parsing. Reverence for specialization works in a direction opposite to that needed for cross-disciplinary communication and understanding.

Federal watershed analysis teams are made up primarily of personnel of participating federal agencies, people who carry scars inflicted by past battles over funding and policy. Diminishing agency budgets have produced competition between disciplines for limited funding, and a budget increase for one subject area often represents a cutback in others. Feelings of collegiality between disciplines are difficult to maintain in such circumstances, and one discipline would be unlikely to push for cooperation with and thus funding of another discipline, even if the other discipline could help them reach their own goals. As a result, we find peculiarities such as the propensity for agency fisheries biologists to do their own geomorphological evaluations of stream channels using methods that geomorphologists know to be wrong. In addition, different disciplines historically have had different goals within agencies, and many professionals see their own roles as being advocates for their area of interest. Some agency wildlife biologists have become known as "combat biologists" whose perceived role is to champion the interests of particular species by fighting off the impacts of agency misdeeds; their constituency becomes a species, rather than the agency or the public.

The drive to specialize also is present at a professional level, and the most respected professionals often are those that have carved out the smallest niches. In addition, every field has complementary needs for affiliation, marketing, and communication, and historically, the development of specialized jargons has contributed to meeting all three needs. If you speak your own language, you are a definable group; your job appears sophisticated and the uninitiated cannot presume to do it; and you can communicate with your peers more efficiently. The advantages of jargon become deficits when a team is working in an interdisciplinary setting; here, the vocabulary must be restricted to words that everyone can understand. Some professionals find this difficult because, in the words of one interdisciplinary team member, "Other geologists won't take me seriously if I don't speak their language." In addition, analytical methods are best developed within the context of a particular discipline, so working at an interdisciplinary interface often means abandoning the established methods. For example, if it is necessary to characterize a few stream channels for an analysis, an interdisciplinary team cannot use the cookbook techniques established by fisheries biologists, geomorphologists, or hydrologists. Instead, an ad-hoc method must be developed that will fill the specific needs of the interdisciplinary question being asked.

Some of the most difficult barriers to overcome are those that arise from the personalities of participants. Working in an interdisciplinary environment quickly reveals how much individuals don't know about the other disciplines, and high-level professionals often are uncomfortable working in an arena in which they appear ignorant. In addition, individuals believe in the importance and relevance of their own field, and it is humbling to work with people who do not necessarily share one's assumptions of one's own importance. Another problem is the natural propensity to prescribe a solution on the basis of the solutions one understands rather than on the basis of what the problem requires. In the words of one observer of problem-solving efforts, "If the only tool you have is a hammer, the whole world looks like a nail."

Making Interdisciplinarity Work

One approach to developing an effective interdisciplinary team is to hand-pick people who are likely to make it work. By understanding the nature of the barriers to interdisciplinary work, it becomes possible to define the personal characteristics and skills needed of interdisciplinary team participants.

Team members must each have a broad-enough view of the overall problem to be able to think beyond the boundaries of their own disciplines. In many cases, the most specialized professionals are least able to see the broader context of the problems. People who have broad backgrounds, such as might be provided by undergraduate degrees in fields such as geography, those with double majors or a broad work experience, and those with "hobby" interests in other fields, are particularly well equipped to see the bridges between fields rather than the fences. Usually allayed with a broad interest is a strong curiosity about how the world works. Someone known for attending seminars or conferences outside their own field or for conversing with other disciplinary groups is likely to be a useful team member.

All participants must have the ability to translate their own field's jargon into language the other team members can understand, and to understand that the same word may have very different connotations and value loads in different fields. In biological and physical sciences, for example, "evolution" is a value-neutral synonym for a trend through time, while in social sciences it represents a theory of social development with strong imperialistic overtones and thus carries a decidedly negative connotation. Each member must be able to recognize the quirks and complexities of their own field and to explain them to a broader audience, and for this, some practical experience in teaching is likely to be useful.

Some individuals have the self confidence needed to wade into the unknown and ask dumb questions. People with the strongest needs to protect their own egos are the least useful on interdisciplinary teams, since the teamwork requires each individual to develop a realistic view of their overall relevance to the problems and to expose their own ignorance by asking the simple questions needed to develop a working understanding of the other fields. Each participant must be able to take on the dual role of expert in their own field and, at first, naive tyro in everyone else's. Any naive tyros who do not expose their ignorance by asking questions are doomed to remain naive tyros.

Self confidence is also needed to allow participants the freedom of abandoning established methods when those methods are not relevant to the problems being addressed. Individuals must have enough expertise in their fields to be able to design methods that peculiarly suit the particular problems they face. In many cases, no suitable methods have been developed. At the same time, individuals must have the humility needed to recognize when their own methods and approaches are inferior to those suggested by others. The traits of self confidence and humility are closely linked: often it is self-confidence that allows humility to be expressed.

A second overall approach to facilitating interdisciplinary analysis is to design the analysis strategy to force interdisciplinary cooperation. In the context of watershed analysis, this might be accomplished by insisting that the report be focused around issues (e.g. flooding) or environmental changes (e.g. vegetation conversion). Each focal area then inherently demands an integrated interdisciplinary evaluation. Also useful might be to provide an example of what a desirable interdisciplinary product looks like. At this point, few good examples exist, so it is not surprising that few teams have a good image of what an interdisciplinary analysis is.

Another overall approach is to provide mechanisms and opportunities to enhance interdisciplinary cooperation. The experiences of federal watershed analysis teams have revealed several techniques that aid in forging interdisciplinary teams.

First, the issue of interdisciplinarity must be discussed so that all team members understand the difference between multi-disciplinarity and inter-disciplinarity. Related to this is the fundamental need for the entire team to develop a shared vision for the task. All participants must at the outset develop a common image of what the product will look like, its scope, and the role it is expected to fulfill.

Second, exercises in "selling" others on the relevance of one's own discipline to the various facets of the overall problem help to develop one's own awareness of the linkages between one's discipline and others. Reciprocally, the exercise provides an opportunity for others to learn of information that may help solve problems in their areas of specialty. If the interdisciplinary team is embarking on a long-term program, it may be useful to schedule an on-going seminar series in which each team member introduces the others to the major ideas in their fields. Such an exercise helps each "teacher" develop a facility for translating their jargon and gives each "student" information needed to translate jargon that does slip through, or even to adopt jargon that is generally applicable.

Third, a field day can be scheduled during which each specialist describes to others what she or he is seeing and inferring at each of a few diverse sites. Such an exercise often discloses fundamental differences in how different disciplines perceive and interpret aspects of the ecoscape. During one such exercise, geomorphologists and biologists realized that they had been talking about two very different parts of the stream system when they had discussed "first-order channels," and this difference could only have been discovered in the field. In other cases, disciplines are introduced to other interpretations of and explanations for environmental changes relevant to their own fields.

Fourth, specialists from several fields can be assigned the task of working together to produce a flow-chart diagram of the interactions that affect a particular issue or that arise from a particular environmental change. This exercise develops a facility for cross-communication as well as provides an analysis tool. Such "mind map" diagrams can become the basis for interdisciplinary analyses by providing a framework for identifying the strongest interactions and for recognizing the most useful information to gather. Such a task was assigned during an interdisciplinary graduate seminar, and student reactions indicated that the same characteristics that made the exercise frustrating were the ones that made it valuable. Students from different fields had very different ways of viewing the problems and found that it took a lot of discussion and argument before they could understand others' points of view. Once understood, however, those points of view deepened their understanding of the problem.

Finally, and perhaps most painfully, the analysis document can be rigorously edited to excise any information that has not been demonstrated to be relevant to the focus of the analysis. Such an approach encourages analysts to test their words continually against the criterion of relevance and to focus their efforts on tasks that lead toward the overall objectives.

Interdisciplinary work is often difficult and frustrating, but the results have value beyond that represented by the report produced. As specialists broaden their understanding of the ecoscape as a whole, they become better equipped to solve problems even within their own fields. But effective interdisciplinary work doesn't just happen; it requires appropriate people, appropriate assignments, and appropriate management.

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Town-Wide Watershed Protection: Identifying and Involving Public and Private Stakeholders

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Introduction

Watersheds as a planning scale unit work well from a technical study perspective but are often less than ideal areas to deal with during an implementation phase. Rather than attempting to create a new jurisdictional unit based on watersheds which cross town boundaries, the current study focused on integrating technical studies on watershed protection within the context of an existing political infrastructure. Defining, identifying, and educating stakeholders involved the use of a multi-phased process which is still underway. The intent is to form action groups of citizens and public officials focused on watershed protection at a localized level.

With strong home rule and weak regional government, many watershed planning efforts in the study region have become little more than "shelf projects"; interesting data gathering efforts that bear little or no fruit during implementation. The Sister Pond Project in North Reading Massachusetts is an attempt to mobilize three small, but diverse, grassroots organizations by focusing on locally familiar geographic units, ponds. A further intent of the project was to help establish a network between the three pond organizations, the Town, and the Ipswich River Watershed Association (a regional watershed organization) for technology transfer and support. Finally, a Lake Management Plan (MADEM, 1994) for each pond will be produced following the conclusion of the public involvement process.

The Sister Ponds

The three study ponds and their watersheds are primarily contained within the Town of North Reading, and are part of the Ipswich River watershed in northeastern Massachusetts. The three ponds are limnologically distinct from one another, have different management histories, and are under different development pressures. Therefore, the overall project design was tailored to address the unique situations of each watershed while still attempting to provide the Town with a cohesive approach towards watershed management.

Martin's Pond, the largest of the Sister Ponds at 37 hectares, is a shallow eutrophic lake in a heavily urbanized part of the community with a watershed area of 1,925 hectares. Martin's Pond is surrounded by residential development built to the water's edge. The area around the pond was first developed as "lake camps" (summer houses or cottages on small lots each served by a well and a cesspool). Most of the original camps have either been replaced by conventional single family homes or winterized, and a public water supply system now serves the community. The homes are still served by cesspools or septic systems. Studies of the pond performed under a grant from the EPA Clean Lakes Program (Anderson Nichols Inc., 1985) indicate that nutrient inputs to the pond are high and that the shallow nature of the water body (mean depth of about one meter and a maximum depth of 3 meters) has contributed to extensive macrophyte growth. The Town of North Reading has a public park near the outlet of the pond which was formerly used as the town beach. This area is still informally used for swimming, but macrophyte growth and concerns about pathogen pollution due to the proximity of wastewater disposal systems to the pond affect the recreational use of the waterbody. Boating, fishing, and ice skating are still popular activities on Martin's Pond. Martin's Pond has an existing pond association and a Town-appointed committee that attempt to address pond-area concerns at the local level. The emphasis of these groups of late had been focused on playgrounds, roads, and conservation land acquisition/cleanup. Within the context of this study, the goal for Martin's Pond was to attempt to strengthen participation in these existing groups, to provide the residents with technical assistance in interpreting and implementing the Clean Lakes Program Diagnostic/Feasibility Study results, and establishing a citizen's monitoring program for water quality.

Swan Pond is a deep, oligotrophic lake in a sparsely developed portion of the Town. Much of the outer areas of the watershed (61 hectares, total) are undeveloped lands currently under tremendous development pressure. The nearshore area is sparsely developed with conventional single family homes on large lots (one acre or more) and a few homes on smaller lots. Significant areas of watershed close to the pond are either wetlands or have been purchased for watershed protection by local governments. The homes around the pond are served by on-site wells and septic systems. The pond is 18 hectares in size and is relatively deep (ten meters or more maximum depth). Swan Pond is part of the water supply system of the Town of Danvers, and is used as back-up storage for Middleton Pond, the main surface water supply for Danvers. Because of its use in water supply, there is a history of water quality testing at the pond for potable water supply parameters and management of pond water levels. There is no history at the pond for the testing of ecologically-significant parameters such as dissolved oxygen, temperature, or secchi disk transparency. The pond is primarily used for fishing and wildlife observation. The Swan Pond Improvement Association is a group of local residents whose primary interest up to this date were centered on road maintenance and utilities. The study goals for this pond included increasing the participation of residents in the pond association, re-focusing part of the efforts of the association on watershed protection, and establishing a citizen's monitoring program for water quality.

Eisenhaure Pond is a small (3 hectares), shallow (1 to 3 meters) pond in a partially-developed watershed of approximately 61 hectares. The pond was created as a farm pond and cranberry bog and was subsequently enlarged by a 2-meter-tall earthen dam and spillway improvements. The recent sale of a farm which controlled a significant portion of the shoreline and watershed has resulted in increased residential development adjacent to the pond. Unlike the condition at Martin's Pond, new "waterfront" development at Eisenhaure Pond has been on one acre lots with significant setbacks from the water's edge. On one side of the pond a sixty feet wide strip of land was deeded to the Town by the developer of the adjacent parcels. This buffer strip provides a greater separation distance between on-site septic systems and the pond than exists at either Martin's or Swan Ponds. The pond is used by local residents for fishing, boating, and ice skating. There is no pond association for Eisenhaure Pond, so the goals of this study were to identify the stakeholders, discuss watershed protection issues with them, and establish a citizen's monitoring program for the pond.

The Stakeholders

Using a small group of already-involved key individuals, the project's first task was to identify stakeholders in common to all three watersheds, as well as those unique to a particular watershed. A further goal was to integrate this study into town-wide planning efforts. Therefore, town officials, board members, and employees were identified as the first group of stakeholders. Because of strong home rule, many functions of town government are carried out by appointed or elected town boards each with a particular mission. For this study it was important to integrate the efforts of two town boards that deal with land use controls, the Conservation Commission (wetlands, waterbodies and floodplains) and the Planning Board (general land use control). Three town departments were also key to the success of this effort. The Planning Department, which reports to the Planning Board, is responsible for town-wide planning efforts and maintains a Geographic Information System for the community. The Water Department has a vested interest primarily in groundwater protection since that is the sole supply for the

Town of North Reading. The Water Department also volunteered to house and maintain equipment purchased for the volunteer monitoring groups. The Assessor's Office was involved in this project as the keepers of property ownership information. We also received cooperation from the Town of Danvers Water Department and from the Town of North Reading Board of Health. These entities maintained historical record of water quality in Swan and Martin's Ponds, respectively, and expressed an interest in involvement with the pond associations.

By using data from these groups, as well as membership information from the two existing pond associations, the next step was to develop a list of residents who lived within 300 feet of each pond. The intent here was to attempt to identify individuals who potentially had the most to gain from involvement in a citizen's group. The authors wanted to first form a core group of people from each pond who could be guided through the process of setting up a neighborhood group and who would receive water quality monitoring training. Therefore, it was important to reach out to those who had daily contact with each waterbody. It also became apparent that, inadvertently, each association was to be comprised primarily of members that had children or grandchildren that frequented the ponds.

Public Outreach and Education

Once the various stakeholders were identified several efforts were organized which aimed to bring them together on a pond-by-pond basis. First, a mailing lists for each watershed were developed from the assessor's information, the pond associations, and town government. A one-page survey form was developed which asked respondents to identify what they enjoyed about living near the pond, perceived problems with the pond or watershed, concerns for the future of the pond, and their willingness to participate in pond/watershed related workshops. This survey form, together with an announcement of a watershed planning workshop, was sent to each person on the mailing list and was distributed to other pond association members and town officials. A collection box for the forms was provided at the Town Hall, or the respondents had the option of mailing the forms to a pre-printed address. Response to this survey was extremely light. Less than ten percent of the nearly 300 forms mailed out were returned. The surveys did have a desired effect, however. About half of the people currently involved in the three pond groups were first made aware of the attempt to plan for the future of their pond via the surveys and announcements.

An evening workshop was then scheduled at a public facility for each watershed. At each workshop a brief history of the pond was presented, but most of the time was spent discussing watershed planning and answering water quality and open space questions. Part of the meeting was devoted to studying ownership plans of the watershed and discussing opportunities for public access and use of the pond. We also spent some time discussing establishment of a volunteer monitoring program, picking sampling stations, and scheduling a field trip to the pond. From each of the three workshops, key individuals who wanted to take a more active role in watershed protection emerged.

Turnout for the Martin's Pond workshop was light, possibly due to the impression that the two committees currently overseeing the pond were adequately addressing watershed issues. Citizen's concerns about Martin's Pond centered on water quality and recreation issues. Residents of the area wanted the pond to be the focus of more attention and use in the community, partially in an effort to convince the Selectmen that the Town Beach should be re-opened as a supervised recreational facility.

There was a good turnout at both the Swan and Eisenhaure Ponds workshops. The development pressure in each of these watersheds probably contributed to this phenomenon. Some Swan Pond residents expressed an interest in pursuing a Surface Water Protection District through Town Meeting, however, the fear of the pond being "discovered" by nonresidents was also strongly expressed. Residents near Eisenhaure Pond also expressed an interest in open space preservation but for the purpose of making the pond accessible to more townspeople. A representative from the major developer in the Eisenhaure Pond watershed attended the workshop and discussed their past efforts in maintaining public access to the pond and open space in the watershed. Continued coordination between the Town, the developer, and the local residents would provide the opportunity to preserve additional open space and recreational opportunities.

Following each workshop a field trip/water quality sampling demonstration was scheduled for a Saturday morning. At each session a local resident made a boat or dock available to their neighbors. The assembled group spent some time making observations about watershed and pond conditions. At each meeting there was equal representation among old and new residents, and parents/grandparents were encouraged to bring their school-aged children. The focus was on making this first "sampling run" a neighborhood/family event; trying to make it a fun outing rather than one more chore that has to be done. After the initial observations/discussions, each session included a water quality sampling and analysis demonstration onshore, and a sampling run on the pond. As part of this project a few pieces of equipment were purchased by the Town for use by the volunteer groups. These included a pH meter, a dissolved oxygen test kit, and a secchi disk. We hope to add a dissolved oxygen meter, Kemmer bottle, and funding for fecal coliform testing (at the Martin's Pond beach) in the next phase of the study. We also plan to repeat the evening workshop and field exercises in the spring and get each group to plan a summer activity focused on their pond.

Summary

The intent of this project was is to draw a variety of stakeholders into a local watershed protection coalition whose mission is consistent with the goals of the regional organization. Keeping the scale small and personal was a key element in bringing otherwise apathetic citizens into the planning process. These small neighborhood pond coalitions are then drawn informally into larger scale planning and protection efforts by training them on a scale that is both meaningful and manageable. They know that they are part of the "big picture", but they have the perceived advantage of not having to deal with a large, "bureaucratic", watershed-wide coalition which may be focusing most of their efforts outside of their Town. The larger-scale watershed coalition then benefits from the micro-management of the neighborhood pond coalition, leaving it free to focus on grander-scale planning efforts. Key elements to the successful implementation of this scheme are: identification of a diverse group of stakeholders from organizations, government, and the general public; involvement of local officials and Town staff;

visibility (public involvement opportunities and "advertising"); knowledgeable guidance in the formative stages of the groups; maximizing the use of existing data and keeping the effort based on watershed science principles; and coordination between the local and regional watershed efforts. Maintaining momentum by planning a variety of activities aimed at the different stakeholders throughout the first years of the groups' existence also appears to be a key factor in preventing the efforts from becoming small-scale shelf projects.

Acknowledgements

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Practical Approaches to Assessing Costs and Benefits: Urban Erosion and Sediment Control as a Case Study

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Introduction

Under the current political climate, governments at all levels are coming under growing pressure to justify their actions in economic terms. Governmental units typically do not have the resources and expertise to conduct formal cost benefit analyses (CBA). Furthermore, applying CBA to situations involving environmental or other social elements produces results that, to many, lack credibility. This is not an indictment of using systematic methods to support public decision making. On the contrary, recognizing that human dialogue in support of decision making is fallible, "methods are ways of structuring this dialogue" to "improve the chances of finding correct answers" (Faludi 1987).

This paper is neither a thorough critique of CBA, nor a "how-to-do-it" about alternatives to CBA. Instead, it presents a broad view of decision-making that provides a context for considering alternative tools. The intent is to help alleviate our real or perceived dependence on CBA. This paper is an abridged version of a working paper on this subject, which is available from the author.

Cost-Benefit Analysis: Strengths and Limitations

Cost-benefit analysis (CBA) is intended for use by the government sector to evaluate alternative public policies. Formal application of CBA generates a ratio of benefits-to-costs, which can be used to rank alternative projects or determine if the benefits of a proposed action are greater than its costs. In principle, CBA seeks to find the most economically efficient outcome. A cost-benefit analysis should also evaluate the distribution of costs and benefits among the various affected parties to identify any serious imbalances.

A proper critique of CBA should be premised on the intended use of the CBA results. In particular, using a CBA ratio as the final arbiter in a public decision is vastly different than using the entire array of CBA information as one of many considerations in the decision making process. The value system that underlies CBA is economic efficiency. This value system is linked to people by notions of aggregating individual consumer preferences as expressed by our willingness-to-pay. Yet, in addition to being consumers, people are citizens who make decisions about their community based on other value systems (religious, cultural, aesthetic, patriotic, traditional, family), which often conflict with the efficiency goal of CBA. If CBA is used as the sole arbiter in a public decision, then economic efficiency is implicitly chosen as the fundamental value system and the other value systems are marginalized. To many, this is a fatal flaw and the most fundamental criticism of CBA. Paraphrasing Sagoff (1994), it would be irrational to base a public decision simply on the basis of some people's intense willingness-to-pay, regardless of the worthiness or reasonableness of the endeavor.

If we relax the premise that CBA be the final arbiter, so that we balance the values of economic efficiency with other values, then a more meaningful discussion can ensue. Consider some of the strengths of the CBA method. First, CBA enforces a systematic framework that guides the collection of information about economic, environmental and social impacts. Systematic frameworks help guide discussion, thereby avoiding "argument at cross-purposes" (Faludi, 1987). Second, CBA, ensures a documented record of the information that entered the decision. Third, if the efficient use of limited resources is the common, overriding goal, then CBA prioritizes resources in an explicit way (Hanely and Spash, 1993). Finally, if the CBA process is open to public discussion, and is flexible in the manner that various impacts are quantified (e.g., using natural units), then the notion of weighing costs and benefits in broad terms is intellectually appealing to just about anyone.

It is understandable that some may find fault with this characterization of strengths. They may feel that the term "cost-benefit analysis" should be reserved for the formal use of CBA, and that more "flexible" applications should be identified by another name. In addition, many will note these "strengths" can also be attributed to any systematic method, thus giving no special significance to CBA.

Critiques of CBA are plentiful (Sagoff 1988, Kennedy 1981, Hanley 1993). Without going into detail, I will note some of them to help develop a context for alternatives. The primary misconception of CBA is that many believe that, if given enough resources, CBA will yield a single, objective result. This misperception is based, in great part, on the allure of economics as a neutral science. At a fundamental level, selecting the CBA tool represents an implicit, subjective choice of the economic efficiency value system. At an operational level, CBA generally requires subjective choices. For example, CBAs entail the explicit definition of a particular perspective, or affected community (a neighborhood, city, county, state, nation). This choice should be made by public officials rather than by analysts. There are no mechanical rules for this choice (Apgar and Brown, 1987). The fact that the decision-maker should be involved in the analysis implies it is subjective, and dispels a second misconception, namely that CBAs can insulate public officials from controversy. Finally, because CBA has subjective operational elements, it is not as consistent as many believe it to be.

In addition to this misconception about CBA, which result in false hopes and misapplications, numerous practical and technical criticisms have been voiced. Most notably, are criticisms of valuing non-market goods, which involve debates on the offer-asking problem (Kennedy, 1981), questions about budget limits on willingness-to-pay surveys, and the issue of existence values in which some people may value the Alaskan tundra even though they never go there. Concerns about valuation represent a specific case of information loss due to aggregation of information into a summary format. From this standpoint, CBA results in an unacceptable loss of information through aggregating information into a monetary format.

There is also the problem of institutional capture, in which those conducting the CBA bias the results in their favor (Hanely and Spash, 1993). The problem of discounting environmental assets to determine costs and benefits over a time horizon also raises technical criticisms (Hanley and Spash, 1993). Environmentally Sustainable Economic Development may also be at odds with CBA. If the working definition of sustainable development is "that at least part of the 'natural capital stock' is non-decreasing, . . . then CBA is in general inconsistent . . . since it explicitly allows trade-offs between consumption goods and environmental quality" (Hanley and Spash, 1993). Sustainable development, by this definition, could be preserved by assuring that any development project with net environmental cost be off-set by projects with net environmental benefits. This would be very questionable in practice.

Finally, as a practical matter, CBAs are notoriously complex. It is important to note that the complexity of CBA has been exploited by past U.S. presidents to stifle agencies by miring them in mandatory cost-benefit analyses (Sagoff, 1993). This is commonly believed to be occurring in the current U.S. Congress with regard to the U.S. Environmental Protection Agency. Such strategic uses of CBA, and questions of its credibility as a decision support tool, raise broader implications.

Although Wengert (1976) was making a slightly different point, his words apply here. He notes, "We have had drummed into us facts concerning the fragility of the ecosystems. I would suggest that our social and political systems may be equally fragile, and that a cavalier disregard of some traditional political values and callous tampering with public confidence in the political system can have equally serious consequences." For those who believe that, in the long run, political institutions represent the appropriate environmental decision making mechanisms, the following potential chain of events would be sadly ironic: A political system, weakened in part by repeated misapplication of CBA, would in turn lose its credibility and become incapable of protecting the environment.

Alternatives to Cost-Benefit Analysis

This section compares and contrasts several settings that an analyst should recognize. This awareness can be used by the analyst to help define the problem prior to considering alternative analysis tools.

Through the political process, we could remove CBA from consideration and have the legislators and executive administrators assume the role of primary arbiter in public decision making. Critics of this scenario rightly ask what systematic methods would be used to ensure objectivity and consistency? According to Sagoff (1996) this is the subject of ongoing research. The topic is far too involved to address here other than to say a few words. First, we should recognize that subjectivity is inherent in the problems being addressed, and in the political process; there is no mechanical process by which to solve society's difficult problems.

Second, our political system has structure based on theories of balancing power, preventing tyranny of the majority, and so forth. It can be a cumbersome process, but that is also by design to prevent rash actions. Third, there are numerous tools and mechanisms that could be applied to improve the political and administrative systems. For example, Haefele (1973) suggests assessing the voting power when creating regional decision-making bodies to address environmental issues, and adopting a 2/3 majority voting rule in environmental decision-making to help prevent errors with irreversible consequences.

First Order and Second Order Problems can be distinguished in terms of scale, complexity, and cross-discipline impacts. Faludi (1987) observes that a lot of problem-solving is compartmentalized due to the need to specialize. But specialization can result in second-order problems that surface as clashes between first-order solutions. Some of the criticism of regulations stem from their compartmentalized implementation as solutions to first order problems, which fail to address second order issues. When this occurs, people often call for cost-benefit analyses, when other planning tools may suffice.

The distinction between Laws or Executive Proclamations versus Implementing Regulations provides a loose guideline for the application of CBA. In general, those who create law should determine the extent to which costs and benefits are to be weighed. They may do this explicitly prior to developing the law, or they may require the implementing agency to weigh costs and benefits, or they may preclude the weighing of costs and benefits explicitly or implicitly. This guideline finds support in Supreme Court record. It is clear that a law can be passed in which implementation is "limited only by the feasibility of achieving" the stated ends, such as a safe and healthful working environment (U.S. Supreme Court, 1981).

The distinction between CBA and Cost-Effectiveness follows from the previous discussion. Consider that in 1987, the Governor of Maryland signed an agreement with neighboring states to reduce nutrients entering the Chesapeake Bay by 40 percent. In committing to this agreement, the cost-benefit considerations were decided; regardless of cost, Maryland agreed to meet the 40 percent nutrient reduction goal. The only remaining problem was to develop a cost-effective strategy to meet this predetermined goal. In a cost-effectiveness problem setting with a targeted goal, CBA is not the preferred tool, regardless of its merits.

The distinction between public and private sector problems is worth mention. The private business sector does not have the same responsibilities to the welfare of society that the public government sector has. In fact, a firm that has publicly traded stocks has legally binding profit obligations to its share holders that can be in conflict with greater societal goals. For this reason, the private sector does not typically use

CBA.

The notion of decision support represents another problem class. Alternative methods of assessing costs and benefits merely intended to collect and organize information. These assessment methods do not in themselves make a decision. Systematic decision support methods can be used in conjunction with the assessment information to help render a decision. Decision support ranges from simple techniques that present or aggregate information, to formal methods such as the Analytical Hierarchy Process, a method of weighting decision criteria (Saaty, 1990); the Delphi method, a group decision making process (Linstone and Turoff, 1975); or Interactive Multi-Objective Programming, a method for generating pareto optimal tradeoff information (Cohon, 1978). If the decision happens to be binary (yes/no), then formal scored Oxford debate could be used. As a general rule, it is better to use decision support tools as an educational exercise and then make the decision by conventional methods such as voting or a consensus process.

Practical Considerations and the Urban Erosion and Sediment Control Case

Up to this point, much of the discussion has addressed general principles that can apply to many quantitative assessments, and not simply that of assessing costs and benefits. There are many practical techniques to aid in assessing costs and benefits when under time and resource pressures. One must recognize, however, that such outcomes will be approximations subject to inevitable criticisms.

As a general guideline, try to involve the decision maker(s) throughout the process. This will allow them to become educated over time, thereby less dependent on the final summary report. Also, adopt an iterative process, beginning with a very simple outline of subject areas to be assessed, and evolving to greater and greater detail based on the interests of the decision-makers. One approach is to create a summary list of positive and negative impacts for all areas of interest, e.g., economic, environmental, social, cultural. Another summary should identify who bears various costs and benefits. While the iterative approach is intended to focus the information search, decision-makers often request information that has marginal value. In such circumstances, the analyst should attempt to show that the cost of collecting the information outweighs the benefits. Another time-honored technique is to "over look" the request.

In Maryland, control of erosion and sediment at construction sites is required by state law. The state can delegate the authority to implement reviews of site designs and site inspections to cities and counties. In this setting, many perspectives can be defined in which assessing costs and benefits might arise. One could seek to review the impacts of existing law or regulations at a state level. One could assess possible regulatory changes at the state level. Other perspectives could be from the residential home builders association, or a local jurisdiction that wishes to assess the costs and benefits of relinquishing authority back to the state. The assessment approach will differ for each of these perspectives. For example, at the state-wide level, what is one person's cost may be another person's profit, thereby canceling out, or representing a transfer, or raising net economic benefit to the state in terms of creating jobs. Yet, from a local perspective, or that of the home developer, this may be of little interest.

As a general guideline, unless you have special funding to conduct serious research, try to build your assessment on the work of others. Two useful pieces of literature pertaining to urban erosion and sediment control (E&SC) costs are Heller, et al. (1992) and Peterson et al., (1993). Other sources of information include local chambers of commerce or economic development agencies (how many small inns and restaurants would be potentially impacted if sediments damaged a county's trout streams?); hobby groups and small businesses (how many in-state and out-of-state fishing licence trout stamps are sold in a county?); trade associations, state business guide books, the telephone book (how large is the local or state erosion and sediment control industry and how many jobs does it support?), local and state government (how many grading permits are issued each year?).

If you are unable to quantify some benefit information, simply list it as a cost or benefit. For instance, E&SC preserves top soil for landscaping and prevents cost of regrading gullies (benefit to construction industry); E&SC for stalls the need for dredging of drainage ditches, ponds and reservoirs (benefit to agency(s) responsible for such maintenance; if properly dredged, flooding will be reduced, which will reduce property damages and potential liability in the event of auto accidents; E&SC will reduce nutrient and turbidity pollution in streams and lakes. Again, the list could be continued.

Finally, anyone conducting assessments of costs and benefits should take the time to review the concepts underlying applications of CBA. Having been around a long time, many case studies exist which serve as a guidelines to help organize the process and provide additional ideas about how to gather relevant information.

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A Conjoint Analysis of Water Quality Enhancements and Degradations in a Western Pennsylvania Watershed

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Introduction

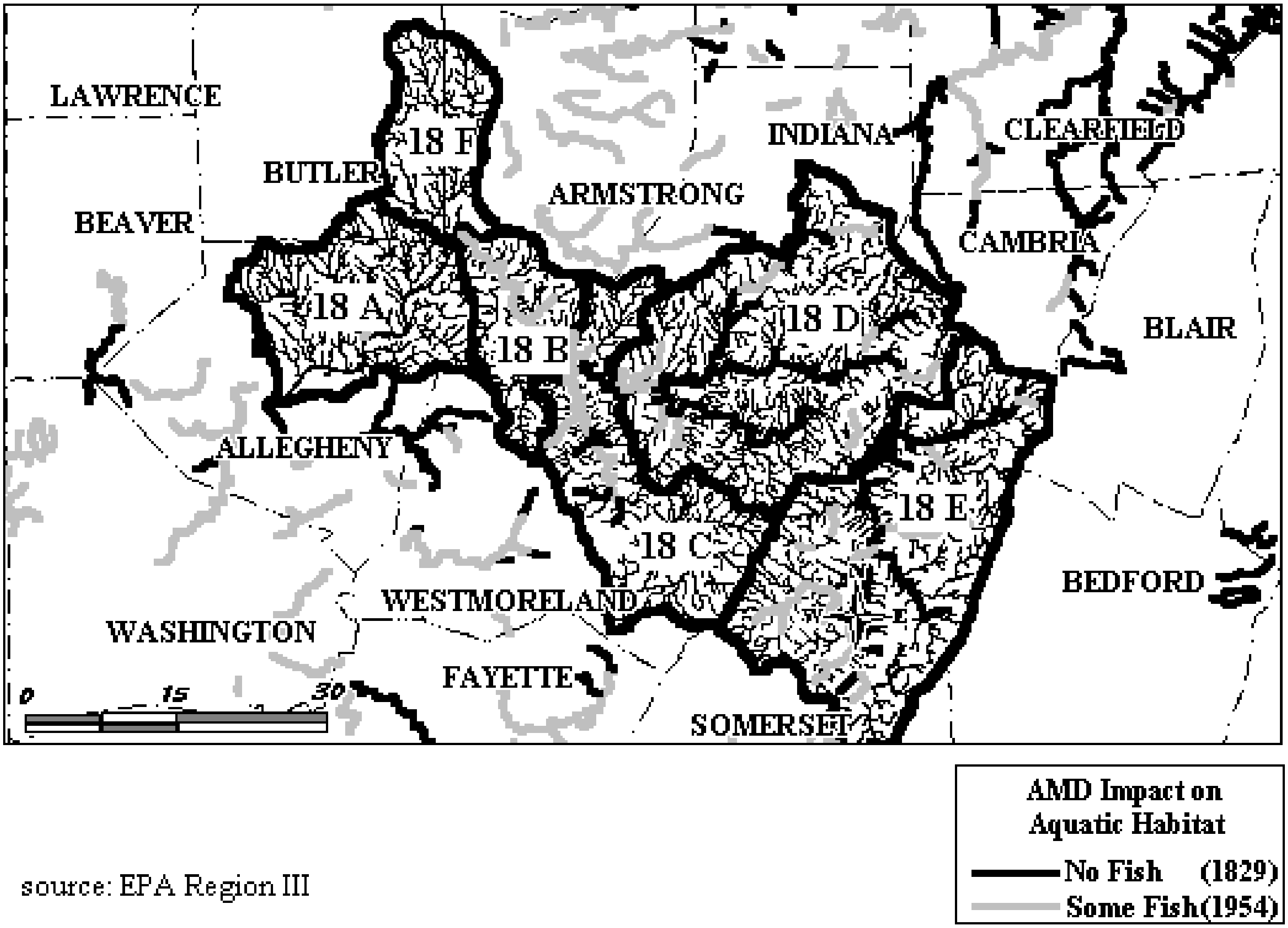
This study utilizes a new methodology for ecosystem valuation, conjoint analysis and extends previous research using conjoint analysis to incorporate the impact of substitutes on the valuation of ecosystem attributes. Conjoint analysis has been used extensively in marketing and transportation studies to examine individual preferences for private and public goods which have multiple attributes. Recently, conjoint analysis has also been used by MacKenzie (1992, 1993) [1, 2] and Gan (1992) [3] to value the attributes of recreational hunting trips and by Johnson, Desvousges, Fries and Wood (1995) [4] to value environmental damages from electric utility plants. This method is particularly appropriate for valuing watersheds which are complex ecosystems with many attributes.

Conjoint analysis may have the additional advantage of removing or reducing quantity-insensitivity biases such as the adding up effect (e.g., if the value of remediating stream A and stream B together is very different from the value of remediating stream A plus the value of remediating stream B given that you are already paying for the remedation of stream A.) [5]. Utilizing a watershed map which makes the quantities of polluted streams explicit and valuing the streams simultaneously using conjoint analysis should reduce or eliminate this bias by reminding the respondents of the larger context.

Previous conjoint studies have used orthogonal main effects experimental designs, i.e., the level of each attribute is evaluated independently of the levels of other attributes so that the individual attributes are uncorrelated. This study extends the methodology by incorporating the effects of substitution on the valuation of the remediation of degraded streams and the prevention of degradation of healthy streams in a watershed (i.e., the value of remediating a degraded stream or preventing the degradation of a healthy stream will depend on the water quality of alternative streams in the watershed). This is accomplished by using a fractional factorial experimental design to create alternative policy packages (i.e., conjoint cards) which will allow for interactions between levels of water quality for alternative streams in a watershed. The values obtained from this methodology represent the total value; i.e., the use value (e.g., fishing) plus the nonuse value (e.g., preserving aquatic habitat for future generations); of remediating or preventing a degradation of a stream within the context of the watershed.

Study Area: Lower Allegheny River Watershed

The study area is the Lower Allegheny River drainage basin which drains 2,394 square miles, includes six subbasins and covers half of Allegheny, Indiana, Cambria, Somerset and Westmoreland Counties as well as some parts of Butler and Armstrong Counties. The basin contains 3,073 stream miles, of which 1,136.4 stream miles were assessed for water quality. Of those stream miles assessed, 553.4 miles fully support statewide protected uses, 112.5 miles partially support statewide protected uses and 459.2 miles do not support statewide protected uses according to the Commonwealth of Pennsylvania 305(b) report (1994) [6]. Of the 583 stream miles degraded (partial and nonsupport) 433.2 of those miles do not support protected uses due to acid mine drainage (AMD). Of the six subbasins, 18C, the Loyalhanna Watershed is the most severely degraded with 281.7 miles degraded (59.31 percent), 100 percent of the degraded stream miles are due to AMD (see Figure 1 and Table 1).



source: EPA Region III

Figure 1. The Lower Allegheny River Drainage Basin & Surrounding Counties.

Table 1. Lower Allegheny River Drainage Basin & Subbasin Characteristics

Subbasin	Area (Sq. Miles)	Total Stream Miles	Degraded Stream Miles	Percent Degraded Stream Miles	AMD	Percent
18 A	323.74	417.00	14.70	3.53	13.70	93.20
18 B	168.73	210.00	43.60	20.76	33.60	77.06

18 C	**367.26**	**475.00**	**281.70**	**59.31**	**281.70**	**100.00**
18 D	**699.92**	**899.00**	**31.40**	**3.49**	**28.60**	**91.08**
18 E	**648.59**	**838.00**	**87.60**	**10.45**	**75.40**	**86.07**
18 F	**186.14**	**234.00**	**0.20**	**0.09**	**0.20**	**100.00**
Total	**2394.38**	**3073.00**	**459.20**	**14.94**	**433.20**	**94.34**

Methodology

The methodology for this study will utilize conjoint analysis to estimate values associated with water quality changes due to AMD (i.e., enhancements from remediation and degradations from mining activities). A fractional factorial experimental design is used to generate alternative policy packages of AMD remediation, degradation and payments or compensations associated with different combinations of water quality changes for combinations of streams. The measure of water quality used will be the EPA classifications of AMD impact on aquatic habitat: severe AMD and no aquatic habitat, and moderate AMD and some aquatic habitat. Other streams are not classified and so data from the Pennsylvania Fish Commission will be used to determine streams which have no AMD and good aquatic habitat.

For the study, three streams in Western Pennsylvania were chosen: Loyalhanna Creek, Conemaugh River and Yellow Creek. The EPA water quality classifications for Loyalhanna Creek is moderately polluted and for the Conemaugh River is severely polluted. Yellow Creek is a trout stocked fishery stocked by the Pennsylvania Fish Commission and is unpolluted by AMD. Four payment levels, $45, $90, $180, and $360 were chosen from previous studies. The three compensation levels $90, $180, and $360 represent WTA compensation for water quality degradations. A full factorial design would produce 33x7 or 189 combinations of water quality and payment or compensation. To simplify the design, four water quality changes were used: severely polluted to unpolluted, unpolluted to severely polluted, moderately polluted to unpolluted and moderately polluted to severely polluted. This reduced the design to 22x3x7 or 84 combinations of water quality and payment or compensation. To further reduce the size of the design, combinations which do not make economic sense were eliminated. The final design used 56 combinations or policy packages. The 56 policy packages were divided into seven blocks of eight policy packages. This design will allow for the estimation of the main effects and interactions between water quality levels in the different streams and the estimation of WTP for water quality enhancements and WTA for water quality degradations.

The study utilizes a map of streams in the study area which indicate geographic locations and current water quality conditions. Each respondent will receive a map and eight policy packages to evaluate. The ratings scale uses five levels to reflect the intensity of preference for the new policy: definitely no, probably no, maybe yes-maybe no, probably yes, and definitely yes.

Conjoint analysis can be used to produce utility-theoretic estimates of willingness to pay (WTP) or willingness to accept (WTA) compensation for changes in water quality associated with AMD using McFadden's (1981) theory of random utility maximization (RUM) [7]. Under the RUM hypothesis, utility is partitioned into a systematic component and a random unobserved component. For example, an individual chooses policy package i over policy package j if the utility associated i with is greater than the utility associated with j so that:

$$V_i \ (WQ_i), \ I-P_i) + \ \mathcal{E}_i \ > \ V_j (WQ_j \ \ I - P_j) + \mathcal{E}_j \qquad [1]$$

or

$$V_i \ (WQ_i), \ I-P_i) \ - \ V_j \ (WQ_j \ \ I - P_j) > \mathcal{E}_i \ - \ \mathcal{E}_j \qquad [2]$$

where

V_k is the indirect utility function for policy package k{i,j}

WQ_k is the water quality for policy package k={i,j}

I is income

P_k is the willingness to pay for a water quality enhancement or compensation for a water quality degradation for policy package k={i,j}

$\mathcal{E}_k$ is the random unobserved utility associated with policy package k={i,j}

In the probabilistic choice framework, the probability that policy package i is chosen over policy package j is given by:

$$Pr\{e_j \ - e_i \ \} < Pr\{V_i \ (WQ_j \ I-P_j) \ - \ V_j \ (WQ_j \ I \ - \ P_j)\} \qquad [3]$$

Given a functional form for V and an assumption regarding the distribution of å , maximum likelihood estimates can be obtained for the parameters of the indirect utility function V.

An ordered logit model will be used to estimate the marginal utilities of the indirect utility function:

$$R = \frac{1}{[1 + e^{-Z}]} \qquad [4]$$

where

R is the ratings scale representing the underlying indirect utility index

and

$$Z = \alpha + WQ\beta + (Y-P)\beta_{Y-P} + X\gamma + BLOCK\delta \qquad [5]$$

where

α	is a vector of coeffcients representing the R-1 rating intervals
WQ	is a matrix of dummy variables and interactions indicating water quality changestrom the base for each stream
β	is a vector of the marginal utilities associated with each water quality change for each stream
(Y-P)	is the change in income associated with each policy package
β_{Y-P}	is the marginal utility of money
X	is a matrix of social and demographic characteristics
γ	is a vector of coefficents corresponding to the social and demographic characteristics
BLOCK	is a matrix of dummy variables indicating which block of cards an individual evaluated
δ	is a vector of coefficients associated with which block of cards an individual evaluated

The marginal value (i.e., inverse compensated demand) of a water quality change in stream i is:

$$h(WQ_i, Y - P, X, BLOCK) = \frac{\dfrac{\partial Z}{\partial WQ_i}}{\dfrac{\partial Z}{\partial (Y - P)}} = \frac{\partial (Y - P)}{\partial WQ_i} \quad [6]$$

In the case of a water quality enhancement, the marginal value is the WTP for that enhancement and in the case of a water quality degradation, is the WTA compensation for that degradation. The estimates of WTP for a water quality enhancement can be used to estimated the value of remediating a particular stream or sets of streams in a watershed given the characteristics of the watershed and the characteristics of individuals who live in and around a watershed. WTA can be used for natural resource damage valuation based on the characteristics of the watershed and the characteristics of individuals who live in and around a watershed.

The study is currently in progress. The analysis and results will be presented at the conference.

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The Value of River Protection in Vermont

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Introduction

Vermont's water resources_its rivers, streams, lakes, and ponds_are a prominent feature of the state's rural landscape. These resources are relatively undeveloped, accessible, and of good quality. However, the state's waters have had a history of abuse ranging from dams and diversions to shoreline erosion from poor land-use practices. In many cases, these abuses continue, further degrading our waters.

The constant pressure throughout the state to divert public water for private uses, coupled with an increase in public demand for water-based recreation, has increased the competition for Vermont's waters[1]. Greater competition intensifies decisions about how to best allocate resources across all demands. The purpose of this study is to help guide public decisions on how to best manage water resources by focusing on the economic values associated with nonconsumptive use[2].

How important is the conservation of rivers and streams to the people of Vermont and its economy? How much commercial activity are water-based recreationists generating? How would losses in the quality or quantity of our water resources affect recreation and the businesses that support the recreation industry?

To answer these questions, the National Wildlife Federation and the University of Vermont teamed up to develop a two-part project. Part One focused on water-dependent businesses by investigating the magnitude of economic activity from such businesses and the importance of clean water to business stability and future growth.

Part Two is a case study that focused on recreationists_the clientele of the water-based businesses_who derive benefit from the use and/or existence of the White River. The White River was selected for this study because it is known for its clean water and scenic beauty. It defines one of the state's 17 major drainage basins, one of two free-flowing rivers in the state, and the only major free-flowing tributary to the Connecticut River.

Methodology

Both parts of this study relied on surveys. Part One consisted of a statewide mail survey of 522 businesses that have a direct relationship to water-based recreation (e.g., bait shops, guide services, etc.). The survey also included those service-oriented businesses that indirectly depend upon the resource (e.g., motels, restaurants, etc.). Their customers may come to these establishments because of their proximity to a recreational site. The intent of the business survey was to gather data on: (1) general business characteristics, (2) marketing activities, and (3) perceptions regarding various water policies. The overall response rate was 33%_44% of businesses directly and 18% of businesses indirectly dependent on water resources, respectively.

Part Two consisted of a random sample of two groups of Vermont residents_1500 households in towns bordering the White River and another 1500 households in "all other" towns in Vermont. A 33% response rate was obtained. The White River survey was designed to elicit information on: (1) perceptions of river quality, (2) expenditures directly associated with trips to the river, and (3) user and nonuser value, measured by willingness to pay (WTP), to prevent streamflow reductions3.

Willingness to pay values were obtained using an open-ended form of the contingent value method (CVM). To study the robustness of the results, two hypothetical scenarios were used to measure the value of protecting a river's natural flows: water withdrawal by a resort for irrigation and snowmaking; and, streamflow regulation by the construction of a hydroelectric generation facility. Each scenario depicted two levels of development that would result in two different flow regimes (Water Levels I and II). Both regimes provided less water in the river than the natural river flow, and Water Level II was a lower water level than Water Level I4.

Results

Finding #1: Business Activity that is Dependent on Water Resources

Results of the Vermont business survey show that businesses dependent upon water-based recreation are widely dispersed across the state, usually located in rural communities near particular rivers, and close to recreational sites or access points. Results also indicate that water-based recreation in Vermont is a $108 to $125 million per year business ($47-$64 million and $61 million in annual gross revenues from the businesses that are directly and indirectly dependent on water resources, respectively). These businesses support a range of 1,600 jobs (typically in the winter months) up to 3,500 jobs (in the summer months) per year and generate at least $6.2 million per year in sales tax receipts for the state's general fund. Because these recreational dollars are often spent in rural communities where the water resource is located, the economic contribution of water-based recreation is particularly significant to the rural economic base.

The survey also identified another category of water-dependent businesses which we have termed, "other water-related businesses." This includes boat and angling equipment manufacturers who tend to market their products primarily outside of Vermont. These businesses may not directly benefit from water quality improvements in Vermont, but emphasized how they derive benefits from the public perception that Vermont's natural resources are clean. These businesses generate an estimated $8-10 million annually in gross revenues and provide an additional 100 jobs.

Finding #2: Use and Visitation Rates of the White River

Overall, 54% of the regional and 14% of statewide respondents participated in recreational activities on or along the White River during the last 5 years. Regional and statewide users visited the river an average of 34 and 7 times per year, respectively. The White River recreational activities with the highest participation rates are:

- Swimming and tubing (32% regionally and 5% statewide),
- Angling (31% regionally and 9% statewide),
- Boating (13% regionally and 5% statewide), and
- Indirect uses that include picnicking, sightseeing, walking, and observing nature (44% regionally and 8% statewide).

These results indicate the importance of Vermont's waters for recreational purposes. They also suggest that people who live within the watershed use the river for recreational purposes more frequently than those in other parts of the state. Water-based recreationists in other parts of the state are likely to have other water resources available to them.

Finding #3: The Importance of Water Levels and Water Quality

Respondents to the statewide business survey were asked to rate the importance of water flow levels to their business. Similarly, recreational users in the White River study were asked to rate the importance of water flow levels in meeting their river-based recreational needs. The results in Table 1 show that 74% of businesses and 77% of White River users overwhelmingly affirm the importance of adequate flow levels in the river.

Table1. Importance of Water Levels and Water Quality for Businesses and Users

Importance of:	Very Important	Important	Total
Flow levels-Regional Users	40%	36%	76%
Flow levels-Statewide Users	47%	35%	82%
Flow levels-Overall Users	41%	36%	77
Flow levels for Business	41%	33%	74%
Water Quality for Business	62%	30%	92%

Table 1 also shows that 92% of businesses surveyed believe that qualitative improvements in clean water are important for business. When businesses were asked whether they would prefer a change in the enforcement or increased investment in current water quality standards, 73% of water-related businesses stated that they would prefer an increase in enforcement or investment. These results demonstrate the value of clean water to these businesses and, by extension, its role in providing sustainable jobs and income in Vermont's rural communities.

Finding #4: User Expenditures to the Regional and State Economy

The estimated annual, statewide expenditures on goods and services directly attributable to recreational use of the White River is $35,228,000. The nondurable, trip-related expenditures (e.g., transportation, food, lodging) accounted for 93% ($33 million) of total expenditures. The durable expenditures (e.g., that portion of a canoe or a fishing rod purchase attributed to trips to the White River) made up the remaining 7% ($2 million). The average nondurable and durable expenditure is $49 and $33, respectively. These expenditures support local businesses and generate and estimated $1.9 million in tax revenue for the state.

It is important to point out the differences between Finding #1 ($125 million in annual gross revenues statewide from business activity) and Finding #4 ($35 million in annual, statewide expenditures from recreational users at the White River). Results of the business survey are very conservative. The revenues do not include every water-related business in the state. Not every business, particularly with respect to the indirect, water-related businesses, received the survey. Moreover, this category of businesses did not include businesses such as country, grocery, and convenience stores, that sell nondurable goods like gasoline, food, and drinks that, as indicated from the results of the user expenditure survey, represent a substantial portion of total user expenditures.

Finding #5: User and Nonuser Value of Maintaining River-Flow

Levels

Both users and nonusers of the White River were asked to list their maximum willingness to pay to maintain the natural flow of the river for the two water levels described in each scenario. Nonusers were included in this analysis because previous research on natural resource valuation suggests that people attribute a large share of their benefit to "nonuse" values.

There are basically two types of values people place on natural resources: use values and nonuse values. Use values are those based on an individual's private consumption or use of that resource. The concept of nonuse values arises from the fact that individuals derive value from the river even if they are not "direct consumers" of the resource. A nonuse value is attributed to a resource existing in its natural state, regardless of people seeing or experiencing it. These values represent the aggregate net economic value (i.e., net willingness to pay or consumer surplus) of a given resource by Vermont residents. This type of information therefore should be given careful consideration in policy decisions affecting the state's waters.

Nonuse values include: (1) option value (associated with using the resource sometime in the future), (2) existence value (associated with knowing the resource exists in its natural state), (3) bequest value (of knowing the resource is available for future generations), and (4) altruistic value (concerning the opportunity to allow others to use the river now). Users and nonusers assigned the greatest percent of their derived value (31% and 37%, respectively) from the White River to a desire to bequest the unaltered river to future generations

Results from the willingness to pay survey on the White River were positive and demonstrate a strong public interest in maintaining natural river flows. Table 2 shows that users were willing to pay more than nonusers, and regional households were willing to pay more than statewide households. In addition, with respect to the two different flow regimes (Water Level I and II), respondents were willing to pay more to maintain the natural river flow when presented with the lowest of the two water level regimes (Water Level II).

Table 2. Mean and Total Willingness to Pay Values to Maintain the Natural Flow Level of the White River

	Water Level I		Water Level II	
Users	Average	Total	Average	Total
Users-Regional	$62	$531,000	$70	$595,000
Nonusers-Regional	$25	$183,000	$26	$194,000
Subtotal	---	$714,000	---	$789,000
Users-Statewide	$46	$1,266,000	$49	$1,366,000
Nonusers-Statewide	$22	$3,717,000	$27	$4,519,000

Subtotal	---	$4,983,000	---	$5,885,000

Summary and Conclusion

The increasing public interest in nonconsumptive water-based recreation signifies an important business opportunity for Vermont. Water-based recreation is an important market niche in the Vermont tourism economy, providing a source of jobs, income, and social benefits. This is particularly important in rural, more sparsely populated regions, where other sources of income are limited.

The results of this study should be considered as policy-makers decide how to best manage the state's water resources, given competing interests. It further justifies, in economic terms, why state and federal policy-makers need to protect water resource quality, encourage local and state initiatives to address degraded waters, and offer timely support of legislation that secures protection of public resources.

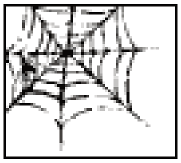
Footnotes

1The 1993 Vermont Recreational Plan - Assessment and Policy Document, p. 50.

2The term, "nonconsumptive" refers to the use of the natural resource that does not alter or threaten its ecological integrity or aesthetic quality. In this case, we use the term to include activities that do not require diverting flows from the river for other purposes, like snow-making or hydropower generation. Anglers and boaters in the river, and hikers, picnickers and photographers along the banks of the river are all nonconsumptive users.

3Nonusers are defined as those who have not participated in recreational activities on or along the White River during the past 5 years.

4Results of the analysis revealed that the method of water withdrawal did not have a significant effect on WTP. Consequently, this analysis focuses on the mean WTP under the two



Characterization of Causes to Changes to Freshwater Inflow for 29 Gulf of Mexico Estuaries

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Web Note: *Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

Introduction

This report provides an inventory of several major watershed activities that potentially affect the volume and/or timing of freshwater inflow to 28 Gulf of Mexico estuaries (Figure 1). The inventory includes characteristics of freshwater impoundments and storage capacities, population trends, consumptive water uses, and freshwater diversions for each estuarine watershed. Where available, the information was presented using a time series format that, in some cases, dates back to the 1930s. The time-series approach documents important incremental changes to freshwater uses and drainage patterns in the watershed and provides historical context for present-day conditions.

The information provided supplements an assessment of long-term freshwater inflow trends to Gulf of Mexico estuaries recently completed by NOAA's SEA Division. Collectively, these two analyses provide an opportunity to evaluate, by estuary, any changes to long-term freshwater patterns against the incremental changes in major water use activities within its watershed. The results of this work were reviewed during a workshop in March 1995 and provide the foundation for on-going assessments of freshwater alteration and its effect on estuarine habitat and pollution susceptibility.

The Inventory of Watershed Activities

The parameters included in the inventory of the major watershed activities that affect the volume and/or timing of freshwater inflow delivered to each estuary reflect information readily available through federal agencies that could be quantified consistently for all Gulf of Mexico watersheds. The purpose is to demonstrate the intensity of freshwater use, alteration, or diversion in each watershed and to compare the relative importance of these activities within the watershed as well as across Gulf watersheds (see Table 1 in Summary).

Data synthesized for this inventory was aggregated using the spatial framework established through NOAA's National Estuarine Inventory (NEI) (NOAA, 1985). The NEI is a series of data synthesis and assessment activities to describe physical environments, biological resources, water quality, pollution sources, and human activities in estuaries and their water sheds. The NEI delineates estuarine watersheds based on the USGS hydrologic cataloging unit system. This approach provides a common spatial structure for consistent data collection and for meaningful comparisons of watershed activities across Gulf of Mexico estuaries.

Impoundment Storage Volume

This parameter is an inventory of more than 15,500 freshwater impoundments in the Gulf of Mexico region and their normal storage volumes. The objective in obtaining this parameter is to establish where these impoundments exist and highlight one of the most important parameters that affect freshwater inflow to the estuarine environment. The information used in the inventory was extracted from a portion of the 1994 National Inventory of Dams (NID) (FEMA, 1994) and adapted to NOAA NEI spatial framework for estuarine watersheds using a geographical information system.

Impounded water has been associated with increased minimum inflows (i.e., intentional releases from the reservoirs) during normally low-inflow season as well as a decrease in the maximum or peak inflows (i.e., water withheld) during the typically high-inflow season. These altered flows, along with issues related to sediment retention and evaporative losses from impoundments, are important to estuarine habitat and resources.

Population Density and Long-Term Population Trends

For this parameter, statistics describing population density and long-term population trends are aggregated by watershed. Population reflects urban land use in the watershed and provides an indirect measure of freshwater use and alteration. Freshwater supports domestic, commercial, and industrial uses in urban areas that potentially stress surface water and groundwater supplies. In addition, urban areas often have extensive regions where vegetative land cover has been replaced by impervious surfaces, thus affecting the volume and rate of water transported through the watershed. Impervious areas increase the rate and volume of surface runoff, contrary to vegetated areas which typically intercept and retain rainfall.

Population data, available from the US Bureau of the Census (BOC), was compiled for the period 1940-1990 and evaluated at 10-year increments. Data containing population estimates for 1970-1990 were available through digital data files, while 1940-1960 data were extracted from County and City Data publications (BOC, 1940, 1950, 1960). BOC provides population estimates by census tract, a small statistical subdivision of a county that delineates all metropolitan areas and other densely populated areas greater than 50,000 persons. For this report, census tracts were assigned to watersheds using a geographical information system that located the census tract centroid with respect to the watershed boundaries defined in the NEI.

Surface Water Withdrawals and Consumptive Water Uses

This parameter summarizes the volume of water withdrawn by use type (domestic/commercial, industrial/mining, thermoelectric power, and agriculture) and the percent of that withdrawal that is considered consumptive. Not all withdrawals are consumptive_for example, some domestic uses (washing cars) and most thermoelectric uses (water used as cooling mechanism) temporarily 'borrow' water and later return it to the surface water source. In contrast, agricultural uses 'consume' much of the water that is withdrawn. For example, in 1985 agricultural use accounted for about 82.5 % of the total amount of consumptive water use in the Nation (USGS, 1987). Evaporation and transpiration of irrigation water are examples of consumptive losses. In addition, some water infiltrates to the groundwater table, effectively causing a 'loss' to surface water.

Estimates of surface water withdrawals were derived electronically from the US Geological Survey's National Water Use Data Dictionary for 1990. The estimates of surface water withdrawals are made for the four major use types. USGS provides this information for each hydrologic cataloging unit, the same spatial unit used in NOAA's National Estuarine Inventory. Thus, the information was readily aggregated to the 28 Gulf watersheds. However, the data were only available for 1990 (no time series was available).

Major Freshwater Diversions

In addition to the watershed alterations described previously, several major freshwater inflow diversions exist in Gulf of Mexico watersheds that represent significant alterations of historic inflow patterns. These diversions may occur intermittently or may be associated with a more permanent regulation schedule. Major diversions (existing and proposed) occur in the following locations; The Central and South Florida canal project, the Tampa Bay by-pass canal, a proposed diversion from the Suwannee River to Tampa Bay, manipulation of waters upstream of Apalachicola Bay, the many diversions of the lower Mississippi River, proposed diversions from the Sabine and Trinity Rivers to San Antonio Bay, a diversion of the lower Colorado River, and the Lower Laguna Madre floodways.

Summary of Results

For many estuaries, it is not possible to identify a direct cause-efffect relationship between the freshwater inflow trends and the watershed activities. However, based on the data collected (Table 1), some general inferences can be made to link the two. The best way to examine freshwater inflow trends and watershed activities in the Gulf region is to divide the entire region into three; the Eastern Gulf Region which includes Florida and Alabama, the Central Gulf Region which includes Mississippi and Louisiana, and the Western Gulf Region which includes Texas.

Six of thirteen estuaries in the Eastern Gulf show a significant change in freshwater inflow. This may be caused by a combination of watershed activities. There is a large increase in population in this region, relatively high consumptive water use due to agricultural activities, and Tampa Bay and Charlotte Harbor both have a high percentage of their flow impounded by many small impoundments.

Three out of nine estuaries in the Central Gulf show a significant change in freshwater inflow. All of these trends show an increase in freshwater inflow for either the high or low flow season or both. This is best explained by an increase in the amount of precipitation in this region. However, there are many diversions from the lower Mississippi River to surrounding water bodies that may affect amount and timing of freshwater inflow to those estuaries.

Eight out of ten estuaries in the Western Gulf show a significant change in freshwater inflow. Six of the estuaries with significant freshwater inflow trends show either a decrease in high flow or an increase in low flow. These are trends highly associated with reservoirs and it is in this region where the 'typical' large reservoirs exist. This is an example of man's most influential impact on freshwater inflow trends.

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Opening More Gulf of Mexico Shellfish Waters for Safe Harvest: Using a Strategic Assessment Approach to Target Restoration Efforts and Build Watershed Partnerships

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The Gulf of Mexico is the top shellfish-producing region in the nation. In 1994, over 27 million pounds of oysters were landed from Gulf waters with a value of about $96 million (National Marine Fisheries Service, 1995). However, over half of the nine million acres of shellfish growing waters in the region has regulatory limitations on harvest (1995 National Shellfish Register, 1996). These closures and limitations are due to a variety of reasons, ranging from administrative rules to degraded water quality.

The Gulf of Mexico Program, a cooperative partnership among federal, state, and local government agencies, industry, and citizens to improve the environmental quality of the region, has recognized the importance of shellfish bed closures as an indicator of the potential decline in coastal water quality. It has identified the restoration of shellfish acreage as one of its top environmental objectives, and the Program partners have pledged to work together to meet the Shellfish Challenge to "increase Gulf shellfish beds available for safe harvesting by 10 percent."

To begin to address the Challenge, the Program formed a team with the National Oceanic and Atmospheric Administration's (NOAA) Strategic Environmental Assessments (SEA) Division to undertake a strategic assessment of the issues impacting shellfish bed closures. The assessment set out to identify, on a Gulfwide basis, the highest-priority strategies for addressing the problem, the watersheds in which these strategies could be most appropriately applied, the major steps and actions needed to implement them, and the priority information and assessment needs required for the strategies to work. The targeting of strategies and information needs was based on the judgment and experience of regional specialistss and the available data that characterizes the scale and scope of the shellfish problem. The data used included the 1995 Shellfish Register database, plus additional information on salinity, freshwater inflow and pollution source location. The underlying goal of the strategic assessment was to produce a plan that will help the Program most efficiently use its resources to meet the Shellfish Challenge. This paper describes the planning and analysis process, presents the results, and discusses the next steps envisioned to move toward restoration.

Why Strategic Assessment?

The Gulf of Mexico is a huge region with well over 2,000 miles of coastline. Within the region there are five states, hundreds of federal, state, and local agencies, and a myriad of other interested groups ranging from environmental organizations to heavy industry. The mix of these jurisdictions and interests along with size of the region and the complexity of the environmental problems makes the use of a systematic approach such as strategic assessment a necessity.

What is strategic assessment? It is problem solving through the application of good planning principles with a broad spatial and temporal view. It is an integrated analysis process that brings together interested parties (stakeholders) with relevant data in a structured framework to produce a sequenced set of activities designed to reach a goal within the constraints of time, resources, and competing priorities. By continually attempting to narrow the focus of attention to the most important strategies and best candidate areas for solving the problem being addressed, it provides a means to simplify the analysis and derivation of possible strategies for complex management issues. It also seeks to maximize the use of existing data, thereby reducing the need for (and cost of) additional data collection, and provide the larger picture of problems and issues necessary to evaluate the importance of, and relationship among, resource issues.

Key steps in strategic assessment include identifying the problem(s); understanding the key factors underlying these problems; assembling the information needed to characterize their scale, scope, and severity; developing and prioritizing strategies to address the problem; reaching consensus on those ideas, and assembling the strategies into a plan of action. For the process to succeed, however, the appropriate personnel, information, and analysis tools (eg., computers, GIS) must be available to conduct the assessment. Without this "assessment engine," the process will not result in a complete and viable plan of action.

Applying Strategic Assessment to the Shellfish Challenge

For the Shellfish Challenge, two regional workshops were organized by the Project Team to bring together federal, state, and local specialists in shellfish management, pollution abatement, habitat management, and the shellfish fishing and processing industry. The goals of shellfish workshops were to develop a series of strategies to help the Gulf of Mexico Program achieve the Shellfish Challenge, target watersheds where those strategies could be applied, and provide some general information on how those strategies could be implemented (Shellfish Challenge Plan, 1996).

Before the first workshop, several key data sets, reports, and assessments were assembled, synthesized into maps, tabular summaries, and charts, and given to each participant in a workbook. Information was included on the harvest classification, area, relative resource abundance, and type and relative importance of various categories of pollution sources contributing to the classification of the 580 growing waters in the region compiled from the responses of state shellfish managers assembled for the 1995 National Shellfish Register; on the location of municipal and industrial discharges and the number of persons serviced by on-site wastewater disposal systems (primarily septic systems) taken from NOAA's National Coastal Pollutant Discharge Inventory; on trends in freshwater inflow, the intersection of growing waters with high and low salinity regimes, and trends in coastal population obtained from NOAA's National Estuarine Inventory; the life history of oysters from the Gulf of Mexico Fishery Management Council's Regional Management Plan for the Oyster Fishery; and on Molluscan Shellfish Harvesting Criteria from the National Shellfish Sanitation Program Manual of Operations and a report by the Interstate Shellfish Sanitation Commission.

These data gave the participants the background needed to help them make better decisions regarding the relative importance of different problems related to shellfish bed closures. Providing this information at the workshop in a readily usable form was an essential step in the strategy development process.

Shellfish Workshop I. At the first workshop, held in New Orleans, LA in April 1995, the 50 participants identified the major issues impacting shellfish bed harvest restrictions, and developed an initial list of 33 strategies to address these issues. To take full advantage of the specific expertise of the invitees, they were then divided into three breakout groups focusing on strategies related to 1) pollution sources; 2) habitat enhancement; and 3) public health and resource management.

After a more detailed review of the strategies, each breakout group ranked them in terms of relative importance to meeting the Shellfish Challenge. The criteria for selection varied by group, but included an assessment of the severity of the problem that the strategy addressed, the regional importance of the strategy, the likelihood that successful implementation would lead to upgrades in growing water classification or increase in shellfish habitat, and the feasibility of successfully implementing the strategy. They then completed a strategy development worksheet for each strategy by briefly diagramming the steps needed to implement the strategy, identifying estuaries in the region where the strategy might be applied, and detailing any impacts the strategy might have on shellfish classifications, harvests, or the ecosystem. The participants then identified, in very general terms, how long it might take to implement the strategy, expected costs, parties affected, institutions involved, and potential constraints on implementation. As a final activity, the results from each breakout session were reported and discussed in a closing plenary session.

Shellfish Workshop II. Sixty participants attended Shellfish Workshop II, which was held in Pensacola Beach, FL in early August 1995. One of the first activities at this workshop was to discuss the list of strategies developed at Workshop I and to suggest necessary modifications. Participants again were divided into breakout groups, and, after additional discussions, conducted a final prioritization of the strategies, selecting one or two strategies as their top picks Gulfwide.

The groups then concentrated on targeting watersheds where the strategies could be applied. Prior to this workshop, the project team had refined the information in the strategy development worksheets, and had used the available background data to undertake an initial targeting of watersheds for their potential as candidates for strategy implementation. The approach to targeting varied for each breakout group, but provided the participants a preliminary result that they could react to and modify. Once the groups had selected and ranked the watersheds as being possible, good, or best candidates, participants were asked to review and prioritize a list of additional information and assessment needs compiled by the project team from the strategy development worksheets completed in Workshop I. This activity was cut short and the workshop canceled at this point because of the evacuation of Pensacola Beach caused by Hurricane Erin.

State Visits. After Shellfish Workshop II, a series of state visits were used to complete the data collection and review process needed for the Shellfish Challenge Plan. Four meetings were held during November 1995 (Alabama and Mississippi were combined). At these meetings, the watershed targeting was reviewed and finalized, priority information and assessment needs were reviewed along with possible sources for the information, and the states were polled as to their interest in participating in future studies to evaluate the feasibility of implementing selected high priority shellfish strategies. The state visits were an extremely valuable way to end the strategic assessment process, as they provided both the Project Team and the state participants an opportunity to focus on the strategies, candidate watersheds, and information needs most relevant to their jurisdiction.

Results

Thirty-two strategies were identified and prioritized by the workshop breakout groups in the workshops. While all of these strategies have merit and can contribute to meeting the Shellfish Challenge, the breakout groups, through the discussions and ranking activities at the two workshops, identified five top strategies on a Gulfwide basis.

Pollution Sources. Two highest-ranked strategies were identified by this breakout group related to reducing inputs of pollutants from septic systems and from runoff from densely populated areas. The goal of Strategy PS-1 is to connect poorly operating septic systems to wastewater treatment plants (WWTPs). The group believed that inputs of fecal coliform bacteria (FCB) from malfunctioning or improperly sited septic systems are a major cause of shellfish harvest restrictions in the Gulf of Mexico.

Individual treatment or septic systems are in widespread use in the region and systems are sometimes located in areas where soils are inappropriate for this type of technology. Under this strategy, individual homes would be connected to a WWTP if one was in a close proximity. If no WWTP existed nearby, construction of a WWTP would at least be considered, taking into account the costs and benefits (both environmental and economic) of installing in a centralized treatment system.

The goal of strategy PS-5 is to reduce runoff containing FCBs in densely populated areas by implementing a variety of best management practices. The strategy was developed to target runoff not only from cities, but also inputs from suburban areas such as shopping centers. The group felt that significant improvements could be made to reduce the impact of densely populated areas on adjacent shellfish growing waters. In addition to FCB, other pollutants such as hydrocarbons and pesticides were cited as components of concern in runoff from densely populated areas.

Habitat Enhancement. Increasing suitable substrate and cultch available in areas of optimal salinity to enhance shellfish productivity was considered the top rated strategy by this breakout group. This strategy suggests that shellfish (i.e., oyster) productivity may be increased in areas of optimal salinity with increased availability of suitable substrate. It targets approved and conditionally-approved harvest areas that are currently either highly or moderately productive. Substrate enhancement is thought to be most beneficial if it occurs adjacent to existing productive reefs or at historically productive reefs if other environmental conditions are satisfied. This strategy was considered generally applicable from the Florida panhandle to central Texas.

Management. This breakout group identified two top strategies. The top resource management approach deals with increasing cultch planting to expand habitat suitable for the production of shellfish, and is very similar to the top habitat enhancement strategy. The top public health management strategy, Strategy M-4, would provide a more accurate indicator of human fecal pollution to better assess public health risks and determine harvest classification for shellfish growing waters. The approach to implementing this strategy is an educational and political process aimed at building support and funding for continuation of the National Indicator Study to develop more accurate bacteriological and viral indicators of the presence of human pathogens.

Watershed Targeting. The goal of this targeting was to identify, at the watershed scale, those estuarine basins where a strategy could reasonably be expected to be successfully implemented. Decisions were based on a combination of data and the professional knowledge and judgment of the state and local specialists. Consistent with the strategic assessment principle of continually narrowing the scope of the problem to reduce its complexity, after Workshop I, targeting was only conducted on those strategies rated as high priority.

In the Challenge Plan, the results of targeting are presented in a large matrix with the 50 watersheds in the Gulf along the top row and the 32 shellfish strategies along the left column. Reading this matrix from left to right shows, for a particular strategy, the number of watersheds in which it can be applied. Reading the matrix from top to bottom shows for a watershed the mix of strategies with a good chance of application in that basin. Decisionmakers and environmental resource managers at all levels of government can use the matrix to better understand and answer questions related to "where and what kind of" shellfish restoration could be undertaken with limited management funds.

Priority Information and Assessment Needs. Over 70 information and assessment needs were identified during the workshops. They represent information required to implement the shellfish strategies. A prioritization process was conducted to identify the most important information and assessment needs. State and federal participants then worked to better define these needs and assess their availability by state. The top six needs were found to be 1) development of an inventory and spatial delineation of present and historic reef locations; 2) development and application of a consistent quantitative measure of shellfish abundance; 3) the compilation of detailed information from the State Shellfish Growing Area Sanitary Survey Reports; 4) improved methods to determine dilution, dispersion and die-off of the indicators of pathogens; 5) compilation of an inventory of septic systems adjacent to growing waters; and 6) an assessment of funding sources for pollution control and shellfish restoration projects.

Next Steps

Strategic assessment has been an extremely valuable process to help stakeholders reach consensus on priority strategies and candidate watersheds for implementation. However, it can not ensure that implementation of a priority strategy will be successful in a particular watershed because the level of information available for the strategic analysis in some cases was not sufficiently detailed to allow the regional experts to determine if all the requisite conditions for successful restoration exist. This level of detailed characterization can only be achieved by a tactical restoration assessment case study specific to the watershed. Such a case study can explore the feasibility of successfully undertaking priority restoration activities by capturing information on the time frame, cost, financing, institutions involved, regulations, impact on stakeholders, indirect impacts, and the role of the Gulf of Mexico Program.

Investigating the "real-world" feasibility and constraints of making one or more shellfish restoration strategies work will provide the states and the Gulf of Mexico Program insight into the potential transferability of implementation techniques and strategies to other candidate watersheds in the region. If the findings are favorable, the case studies will have laid the foundation to proceed with a demonstration project to test strategy implementation in the watershed at some future time. These case studies are a logical next step in promoting the implementation of restoration activities needed to meet the Shellfish Challenge.

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Ambient Environmental Conditions, Pollutant Loads, and Waste Assimilative Capacities in the Patapsco and Back Rivers Watershed, Maryland, USA

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The Patapsco and Back Rivers Watershed drains Maryland's most heavily urbanized and industrialized area. The Watershed spans 685 square miles across four counties and encompasses the entire City of Baltimore. Forty-four percent of the Watershed is presently developed, 24% is in agricultural use, and 30% is under forest cover. The sediment, water quality, and ecological conditions in the watershed reflect the intense urbanization and intrusive land uses of the past 250 years and exhibit some of the most degraded conditions in Maryland waters and Chesapeake Bay tributaries. Although hundreds of studies have been conducted by federal, state, regional, and local agencies for the purposes of resource and watershed management and water supply, no attempt had been to compile, assess and compare the results.

Present Conditions and Historical Trends

The Maryland Department of the Environment's (MDE) Chesapeake Bay and Watershed Management Administration therefore commissioned a study to compile and synthesize information from over 300 existing sources on various historic, current or projected environmental conditions of the Patapsco/Back Rivers Watershed. The objectives of the study were to (1) to assess current pollutant loadings, (2) to identify data requirements, and (3) to develop recommendations for addressing the data needs. In addition, the project was conducted to support ongoing efforts within the Chesapeake Bay Program to quantify and address nutrient and toxic pollutant issues in this Watershed. The project also developed a Geographic Information System (GIS) data base of physical watershed characteristics.

Previous studies of ambient conditions indicated elevated nutrient levels resulted in algal blooms occur in both the Back and Patapsco Rivers. Concentrations of some metals (Hg, Cu, Ni, and Pb) in the Patapsco River have exceeded the marine chronic criteria, and six metals (Cu, Cr, Hg, Ni, Pb, and Zn) have previously been identified as being of concern for water quality. Aquatic organisms in both the Back River and Baltimore Harbor have accumulated elevated levels of at least six metals (As, Cd, Cu, Pb, Se, and Zn), five pesticides (chlordane, DDT, dieldrin, hepatoclor epoxide, and lindane), perhaps PCBs, and some PAHs. Based on bioassay results, sediment toxicity in Baltimore Harbor and its tributaries is patchily distributed, and more information is needed on factors contributing to toxicity. A sediment toxicity index (calculated as the sum of toxicity units) indicated that sediment toxicity was widespread and patchy, though generally decreasing in a downstream direction. More extensive bioassay and bioassessment studies are needed for a comprehensive understanding of the condition of living resources in Baltimore Harbor and Back River.

No groundwater loadings data were found. Groundwater may contribute a significant portion of stream baseflow, and potential sources of groundwater contaminants exist throughout the Watershed. Nutrient loadings are of greater concern in the western half of the Watershed where septic system discharges will be continued and agricultural uses are widespread. Loads of toxic chemicals are important on a local scale, particularly in the eastern urbanized and industrialized areas of the Watershed. Concerns regarding groundwater contamination and loadings may be exacerbated by water supply pumping.

Numerous previous estimates of pollutant loadings for the Watershed exist, but no comprehensive assessment of nutrient and toxic loadings for the entire study area was found. Several studies presented calculated estimates for various areas; however, the only available empirical data for current loadings were nutrient discharges from point sources.

Point sources have been and continue to account for the predominant portion of loads to the Watershed _ 79% of combined total nitrogen (TN) and 69% of combined total phosphorus (TP). Point source nutrient discharges have decreased by 70% and toxic discharges have decreased by 95% since the 1970s. Recent estimates indicate that metals represent the predominant toxic point source loads by volume and are discharged throughout many of the Watershed segments, but organic chemicals represent the greatest discharge of cumulative toxic units and their discharges are very site specific. The best available estimates indicate that 0.385 million lb/yr of toxic chemicals are discharged from point sources in the Watershed.

MDE estimates indicate that nonpoint source TN loads have increased by 0.2 million lb/yr since 1985. The Patapsco River freshwater drainage area appears to contribute the largest nutrient runoff loads due to its large size and extensive agricultural lands in the headwater reaches combined with intense urban areas in the lower reaches. No estimates of toxic nonpoint source loads were found for the entire Watershed; however, sub-basins with the most intense urban and industrial development would be expected to generate the largest toxic runoff loads. MDE estimates that 14 million lb/yr of TN and 0.74 million lb/yr of TP are contributed to the waters of the Watershed from point and nonpoint sources.

Estimates indicate that atmospheric deposition loads of nitrogen are very significant, with loading rates averaging 13.5 lb/ac/yr. Atmospheric loading rates for metals (i.e., Zn, Pb, Cu, and Cr) are relatively small (less than 1 lb/ac/yr). Atmospheric pesticides of concern include alachlor, malathion, and metachlor, and others.

In general, existing environmental data sets for the Watershed were found to be either spatially incomplete, temporally discontinuous, or methodologically inconsistent, conditions which together limit the usefulness of past studies for determining basin wide or historic trends. An extensive listing of data requirements was then prepared with which to fully assess existing conditions and trends and to develop management and remedial plans.

Field Data Collection, 1994-1995

Based on the recommendations of this historical data analysis, MDE subsequently sponsored an extensive data collection effort in 1994 and 1995 for conventional water quality constituents in the estuarine waters of Patapsco and back Rivers, for flow and quality at the fall line of the Patapsco River, and for the quality of effluents from major point sources discharging into the estuaries. Those data are presently being analyzed. Results of preliminary analyses indicate that conditions are improving, particularly in the Back River. However, that estuary is still severely eutrophic.

The historical and recently collected data on the watershed are presently being used to address some critical resource management and wasteload allocation issues affecting the Patapsco and Back River estuaries. Two major point sources, the two Publicly Owned Treatment Works (POTWs) operated by the City of Baltimore, are presently the objects of a comprehensive wastewater Master Facilities Planning effort to estimate the system capacities needed to serve the Baltimore metropolitan area to the year 2020 and beyond.

Major questions to be addressed concern:

- the assimilative capacities of the two estuaries for current and expected future loads of N and P;
- the total contributions of N and P from the Watershed to the Chesapeake Bay; and
- the contributions of metals from the POTWs, relative to other point sources, nonpoint sources, and sediment fluxes in the estuaries.

Field Data Collection, 1996

To address specific data gaps related to the management of the POTWs and preparation of the Wastewater Master Facilities Plan, the City of Baltimore is sponsoring a supplemental data collection program in 1996. The objective of the 1996 field program is to collect the remaining data needed to prepare mass balances for N, P and nine metals. The field collection program includes the following components.

- Tributary Loads at the Fall Lines: Base flows (dry weather) and storm events are being monitored and sampled weekly at the fall lines of the three major streams feeding the Patapsco Estuary: the Patapsco River, the Jones Falls, and the Gwynns Falls; and Herring Run, the major freshwater input to the Back River. Flows are monitored continuously and automated samplers collect composite samples that are analyzed for several forms of N, P and carbon, chlorophyll a, physical parameters, and total/dissolved forms of the nine metals. These tributary samples provide integrated measurements of the combined inputs of Watershed nonpoint sources to the estuaries.
- Water Column Concentrations: Water column concentrations of the same constituents are being collected at the same locations sampled by MDE in 1994-1995. Metals sampling and analysis is following some aspects of EPA's new "clean" protocols, to reduce the effects of sample contamination.
- Sediment Concentrations: Sediments at selected stations in the Back River and Patapsco River estuaries are being sampled for carbon, nutrient, and metals concentrations.
- Sediment Fluxes: At several locations, intact sediment cores are being collected and incubated in the laboratory to measure oxygen metabolism and fluxes of N, P and carbon dioxide. Replicate sediment cores are also being used to measure the fluxes of selected metals into the water column. The large reservoirs of nutrients and metals in the sediments of the estuaries, coupled with the

potential for efflux to the water column, suggest that the sediments could be a significant contributor to water quality problems in the overlying water column. Further, preliminary analyses suggest that the POTWs may be minor contributors to metals concentrations in the estuaries, when compared to sediment fluxes.

Mass Balance Analyses

The combination of the historical status and trend analyses, MDE's 1994-1995 sampling effort, and Baltimore City's 1996 sampling provides a comprehensive tool that can be used to quantify the relative contributions of all sources of pollutants to the estuary. Mass balances are being prepared as the first step in placing the manageable inputs (especially the POTWs) in the context of the other contributors that may be more difficult to control. This holistic perspective will allow the prioritization of funds available for management. The combined data set and mass balances will also serve as a basis for a comprehensive Tributary Strategy for the Watershed, which is being developed under the Chesapeake Bay Agreement to identify cost-effective measures to reduce nutrient inputs to and improve the water quality of the Chesapeake Bay.

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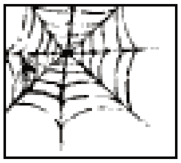

Note: This information is provided for reference purposes only. Although the information provided here was accurate and current when first created, it is now outdated.

Can a Community Based Watershed Plan Help Ensure Safe Drinking Water?

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Introduction

The U.S. Environmental Protection Agency (USEPA) has promulgated several new drinking water regulations following the Safe Drinking Water Act Amendment in 1986. These new regulations are intended to provide stronger safeguards against potential risk from waterborne diseases by emphasizing frequent water quality monitoring and source water protection. The regulations have been developed primarily for large water supply systems (population greater than 10,000) and provided little flexibility to accommodate unique situations frequently encountered with smaller systems.

This problem with inflexibility became particularly evident after the Surface Water Treatment Rule (SWTR) was promulgated. For example, the SWTR requires water supply systems utilizing a surface water source, or a ground water source which has direct surface water influence, to provide filtration treatment. The only systems which can be exempted from this requirement are those that meet the filtration avoidance criteria (FAC). The intention of the FAC is to ensure that unfiltered water supply systems have adequately protected watersheds to provide high source water quality. The FAC provides no exemptions for systems which draw from very pristine water sources, and/or systems with water supply sources located in very pristine watersheds.

Project Background

The Town of Pinedale, Wyoming is situated on the western skirt of the Wind River Mountain Range, 120 km south of Yellowstone Park. The population of Pinedale is 1,200 and is experiencing a growth pulse, characteristic of many small western communities. The town drinking water has historically been a surface water supply originating from Fremont Lake located 3 km north of the town. The water intake for the drinking water supply is located in the southwestern corner of the lake, 180 meters from shore, at a depth of 20 meters. Water is chlorinated and piped to the town distribution system.

Fremont Lake was formed by glacial scouring and blocked at the outlet by a terminal moraine. The lake lies at an altitude of 2,260 m, having a volume of 1.69 km3 and an area of 20.6 km2. Fremont Lake is elongated, having a length of 8.14 km, a width of 1.57-2.08 km, and a maximum depth and mean depth of 185 m and of 82 m respectively. The lake has been characterized as oligotrophic (pristine) with dissolved solids concentration of 12.8 mg/L. Detailed chemical profile data describes a lake with ion concentrations at extremely low levels, indicating a very dilute system (Rickert and Leopold, 1972).

As would be expected from the lake chemistry, the watershed is also reasonably pristine. The 196 km2 drainage basin originates from the western slope of the continental divide and is largely comprised of the Bridger Teton National Forest Wilderness Area. Pine Creek enters the northern end of the lake and serves as the only significant tributary. The watershed has moderate recreational usage and the U.S. Forest Service (USFS) has provided grazing permits for this area of wilderness land.

Water quality problems originating for the drainage basin are not expected to be significant. Problems from recreational usage (boating and camping), a tourist vacation lodge and small marina, and some housing development adjacent to the lake pose the most immediate threat to the lake and water quality which could potentially affect the drinking water supply.

The Surface Water Treatment Rule and Filtration Avoidance Criteria Requirements.

The SWTR primarily focuses on the biological contaminants such as Giardia lamblia, viruses, heterotrophic plate count bacteria (coliforms), and Legionella. Furthermore, the SWTR specifies a multiple protection barrier using filtration and disinfection as the best treatment techniques, as an alternative to establishing maximum contaminant levels for these microorganisms. For Pinedale to comply with the SWTR and be allowed to remain unfiltered, the municipality must maintain a very pristine water source, provide adequate disinfection to achieve inactivation of 99.9 percent (3-log) of Giardia lamblia cysts and 99.99 percent (4-log) of viruses at all times, and maintain a watershed control program.

In 1991 the SWTR went into effect, and the town of Pinedale was notified that it must comply with the rule. However, the town made a decision not to provide any treatment to their drinking water beyond chlorination. Their determination was based upon several factors; the cost of a filtration system would exceed $1 million, which is very expensive for a small community; there had been no history of Giardia contamination; and the waste generated from the filtration backwash would create a disposal problem impacting their local environment.

EPA Region VIII was very concerned about the possible health risks which may result from lack of compliance to the filtration rule. Even though the water supply is an oligotrophic lake and the watershed is mostly comprised of wilderness area, there is sufficient human and animal (wild and domestic) activity around the water supply and in the watershed to create a threat of contamination. In addition, the USFS stored and used herbicide to control weeds along their stock trail which was considered a possible contamination source. Therefore, EPA strongly recommended that the town install a filtration system.

After consulting with EPA, the town determined that they could comply with all the criteria to remain unfiltered, after system improvements, with the exception of developing and maintaining a watershed control plan. The Pinedale community leaders agreed to work with EPA on formulating and implementing a plan to meet the FAC. In addition, it was agreed that the town would also install water meters to encourage water conservation and evaluate the option of providing filtration.

Watershed Control Plan Development

While working with the town to determine the appropriate actions needed to meet the FAC, the December 1991 statutory deadline expired. In order for the town to continue the effort without violating the SWTR, EPA issued an administrative order on consent (AOC) to Pinedale in June, 1992 to allow the town more time to meet the FAC. This AOC is an enforceable bi-lateral agreement between Pinedale and EPA, which was developed based upon an improvement schedule proposed by the town. The AOC was amended in April, 1994 to modify the time table following the development and approval of a water supply master plan. This amended AOC required the town to implement a watershed control program by July 31, 1994; provide backup power supply for disinfection equipment by June 30, 1995; and complete system modifications to provide adequate disinfection by December 1, 1997.

EPA Region VIII developed a watershed control program guidance to assist the town with this undertaking. The guidance included the following major items:

- Delineate a watershed base map.

- Identify animal types and populations which have potential to transmit pathogens.

- Identify human activities.

- Assess potential risk of human and natural activities on the watershed and water quality.

- Develop written agreement with landowners to oversee activities.

- Prohibit activities near water intake structure.
- Prohibit sewage discharge in the lake.
- Develop and implement a water quality monitoring program.
- Develop a long term plan to commit resources to implement the watershed control program.
- Submit annual report for EPA's review.

A water quality monitoring program was identified as an essential component of the plan so as to determine if Fremont Lake was being affected by human activities around the lake and in the watershed. An agreement was reached to monitor three times during the ice free season at four sampling locations based upon potential sources of contamination.

In addition, as part of the watershed plan, the town requires wastewater leach fields be drained away from the basin. All septic tanks in the campgrounds are pumped and hauled away to prevent sewage contamination to the lake. In addition, the town installed buoys to prohibit boating near the water intake area. Signs were posted around the shoreline to inform the public that Fremont Lake is the Pinedale drinking water supply and request that the public refrain from any activities which would lead to contamination.

In order to facilitate the watershed plan, there were memoranda of understanding (MOU) developed and executed between the town and each of the following public entities.

  - U.S. Department of Interior, Bureau of Land Management.
  - USFS, Bridger Teton National Forest.
  - Board of County Commissioners of Sublette County, Wyoming.
  - Wyoming Game and Fish Department.

Activities on public lands will be governed by each MOU and the regulations of Wyoming Department of Environmental Quality. In addition, there are 11 private landowners in the Lake Ridge Subdivision on the east side of the lake. Activities on private land will be governed by applicable Sublette County ordinances. Any revisions to the management activities and proposed improvement must be reviewed by the town and EPA.

The watershed control plan also addressed emergency action if a contaminant is discovered in the water supply. Public notice are to be provided through electronic media, hand delivery, and/or newspapers to instruct the users in the event of an emergency.

Summary

Over the last twenty-five years, EPA has been most successful in dealing with environmental problems when working closely with all stakeholder. In addition, proactive approaches in dealing with potential pollution problems have also proven to be highly effective, when there has been community involvement and agreement. Historically, the drinking water program has relied on an enforcement strategy to achieve the program goals. However, as this pilot effort has thus far indicated, success can be realized when working closely with the community to resolve conflicting views.

This pilot project continues to provide a valuable learning experience for the EPA drinking water implementation program. This special process provided and continues to provide the opportunity for Pinedale to work with EPA on their potential problems without violating the regulation. Hopefully, this will prove to be a good example of resolving an environmental problem through a partnership and community based approach, alleviating the need for an adversarial enforcement action to achieve health and environmental protection.

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A GIS-Based Watershed Survey Used To Develop Protection Strategies For Elsinore Valley's Drinking Water Source

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The Elsinore Valley Municipal Water District (District) supplies water to over 75,000 people in western Riverside County in Southern California. The District obtains water from wells, imported water sources, and the San Jacinto River at Canyon Lake. The District obtains 15 percent of its water supply from Canyon Lake and the remainder from local wells and imported water.

Introduction

This watershed sanitary survey examined surface water issues related to:

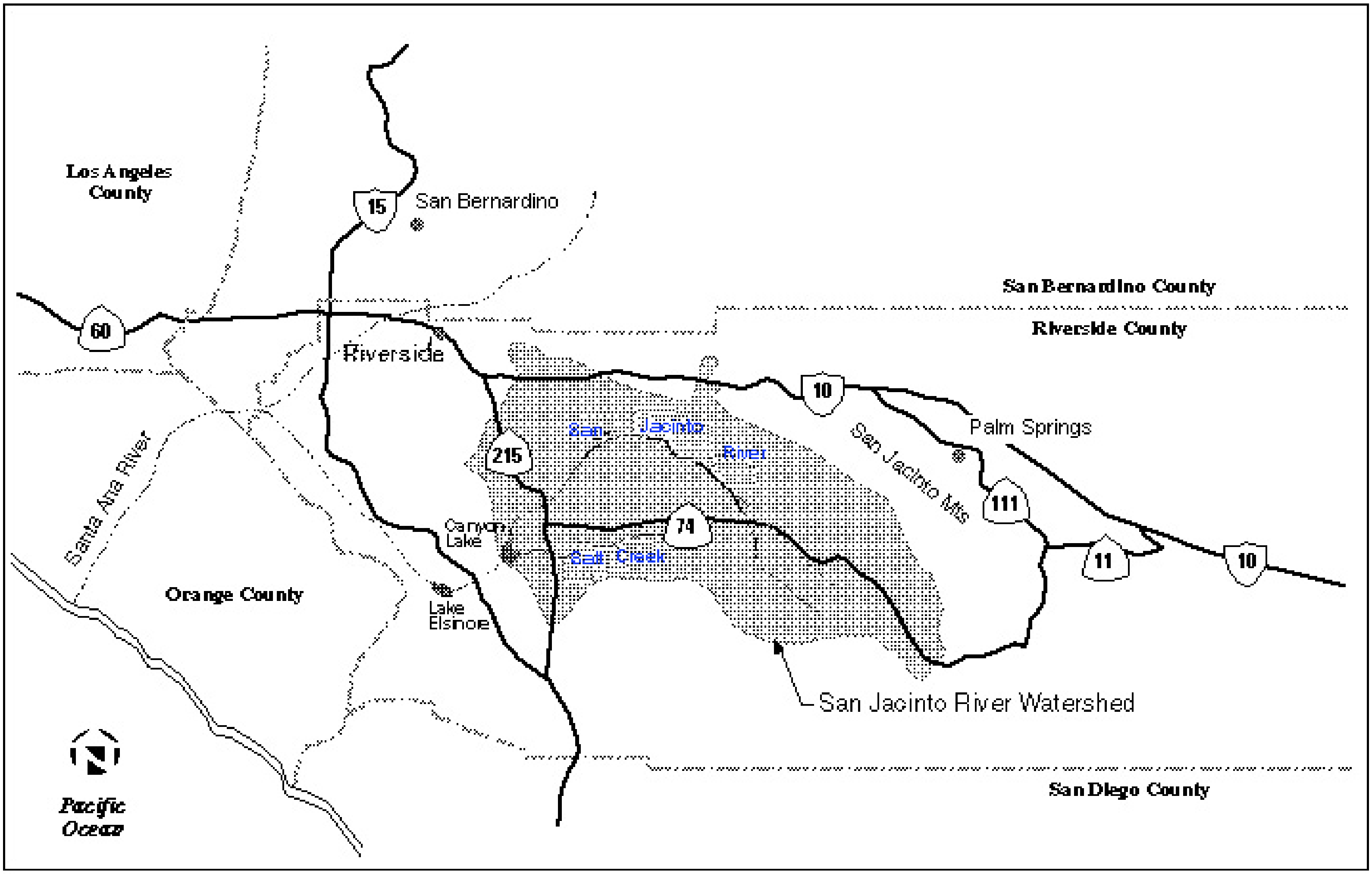
- Potential contaminant sources in the watershed.
- Watershed controls and management practices by the District and other agencies.
- Water quality conditions and water quality monitoring programs.

An important element of the survey was data from the County of Riverside Geographic Information System and the ability to produce maps to highlight various combinations of land uses. The survey also employed field surveys, discussions with regulatory agency staff, and review of available reports.

Watershed And Water Supply System

The 718 square mile watershed has two main watercourses as shown in Figure 1. The San Jacinto River and Salt Creek receive runoff from a wide variety of land uses. Although the dominant land uses are open space and agriculture, the watershed also contains the urban infrastructure to support five incorporated cities and a large military base. The eastern portion of the watershed is characterized by mountainous public lands owned by the U.S. Forest Service and Bureau of Land Management

(BLM).



Location Map
Figure 1

Figure 1. Location Map.

The 1995 estimated population of the watershed is 360,000. The watershed is within the fastest growing county in California and projections of future land uses show definitive trends toward replacing much of the agriculture and privately owned vacant lands with residential land uses.

Water from the watershed is treated at the Canyon Lake Water Treatment Plant, a 9.1 mgd facility consisting of coagulant chemical addition, flocculation and sedimentation, filtration, and disinfection.

Potential Contaminant Sources

A wide variety of potential contaminant sources were reviewed as part of this study. The potential contaminant sources were then correlated with water quality data where possible to help assess the relative importance of each source.

Table 1. Summary of Potential Contaminant Sources in the San Jacinto River Watershed

Potential Contaminant Source	Relative Risk Rating	Effectiveness of Containment, Mitigation or Treatment	Remarks

Concentrated Animal Facilities	High	Fair	Large number of dairies; containment pond effectiveness questionable.
Wastewater Collection Systems	High	Good	Rehabilitation nearing completion for Canyon Lake system.
Septic Tank Systems	High	Poor	Quail Valley area is primary concern.
Recreational Use-Canyon Lake, BLM Land Adjacent to Lake	High	Fair	Peak recreational use season corresponds to peak water use from lake; no activity allowed within 1,000 ft of intake.
Urban and Industrial Runoff	Medium	Fair	Stormwater permit process in early stages; rapid growth anticipated.
Agricultural Crop Land	Medium	Fair	Little evidence of contamination at intake; irrigation practices reduce tailwater and runoff potential.
Solid and Haz. Waste Disposal Sites	Medium	Variable	Municipal landfills only, no haz. wastefacilities; contaminated runoff from one closed landfill documented.

Table 1 lists the potential contaminant sources rated as having high or medium potential for contaminating the drinking water source. Sources having high potential are described below. None of these sources is now degrading the water quality of Canyon Lake to a degree that results in violations of established water quality standards at the raw water intake. These are, however, the most likely contributors of pathogens and nutrients including total organic carbon (TOC).

Concentrated Animal Facilities

The watershed contains over 52,000 head of cattle and millions of chickens in concentrated facilities. Runoff from many of these facilities, if not contained in accordance with water quality regulations, can potentially contribute to pathogen contamination as well as elevated levels of nutrients such as nitrogen, phosphorus and TOC. Excessive nutrient input to Canyon Lake can degrade water quality by promoting algae blooms.

Water quality analyses at the Canyon Lake intake indicates the presence, at low levels, of coliforms and two particularly noteworthy organisms: Giardia and Cryptosporidium. These two can cause usually non-fatal intestinal illness in humans. However, the numbers of these two organisms found in a very limited sampling program indicate that at the present time, raw water pathogen contamination has not become a problem in Canyon Lake. The levels of pathogens in the water are not unusual when compared to typical watersheds that supply potable water systems in the U.S. The lake has experienced a trend of rising total coliform bacteria over the past six years.

Canyon Lake Wastewater Collection System

Sewers and pump stations around and under Canyon Lake have leaked in the past and are now undergoing a rehabilitation program. Some sewers are located under the lakebed or close to the shoreline and could directly contaminate the lake if leakage occurs. Any leakage could result in higher than usual pathogen contamination at the raw water intake.

As noted above, although the water at the plant intake has shown low levels of pathogen and coliform contamination, the levels are in the typical range for watersheds which serve as potable water sources in the U.S. The collection system rehabilitation work will be complete by the end of 1995 and should reduce the occurrence of pathogen organisms at the raw water intake.

Failing Septic Tanks

Septic systems in the Quail Valley area near Canyon Lake have a history of failure. There is the potential for ponded septic tank effluent to become surface runoff during rainstorms. This could result in elevated pathogen levels and nutrient levels in Canyon Lake, in the same manner as would be true for a sewer overflow or exfiltration.

Recreational Activities

Body-contact recreation in the lake and boating activities have the potential to cause pathogen contamination of the lake water in the event that shore toilets are not used or boat holding tanks fail or spill. Unlike the previous potential contaminant sources described earlier, however, these activities are more likely to cause contamination in the warmer months of the year when rainfall is infrequent and lake recreational use is at its peak. During major rainstorms that occur in the winter months, the risk of contamination due to recreational activities is reduced.

As is true for the previously mentioned potential contaminant sources, recreational activities could be contributing to the upward trend in total coliforms at the raw water intake.

Recommendations

The watershed water quality is typical for surface drinking water sources in the U.S. Although there do not appear to be immediate water quality concerns or need for drastic action, the District will work together with regulatory agencies responsible for water pollution control and land use management to better implement current water quality protection programs and existing regulations. A number of actions are being implemented.

- Land Use Changes_The District will provide input comments to the Environmental Impact Reports generated by projects and General Plans developed by cities in the watershed with respect to water quality impacts. District input can help focus attention on the need to properly contain contaminated runoff.

- Wastewater Collection Systems_Through a rehabilitation program, the District is correcting system deficiencies in pump stations, faulty sewers and manholes which cause overflow or excessive exfiltration. Additional water quality monitoring and logging of spills and subsequent coliform test results is recommended.

- Failing Septic Systems_The District will work closely with stakeholders to negotiate a sewering plan with the Eastern Municipal Water District for the Quail Valley area. Long term plans call for future developers to finance most of the needed improvements for new homes, but do not address the need to install sewers in existing developments to connect to proposed trunk sewers.

- Urban and Industrial Land Use Runoff_The District should participate in the National Pollutant Discharge Elimination System (NPDES) municipal stormwater permitting process by requesting the Santa Ana Regional Water Quality Control Board (Regional Board) to require the Riverside County Flood Control and Water Conservation District and co-permittees to step up compliance with requirements, monitoring the implementation of Best Management Practices, and requesting the addition of water quality monitoring stations to the San Jacinto River and Salt Creek, upstream of Canyon Lake. The District should also request the Regional Board to step up monitoring and enforcement of industrial and construction activity stormwater dischargers.

- Agricultural Crop Land Uses_Should pesticide levels in the treated water appear at levels approaching the Maximum Contaminant Levels (MCLs), the District should initiate a public information and education effort directed to pesticide users, particularly the citrus growers in the watershed.

- Concentrated Animal Facilities_Through coordination with the Regional Board, the District now receives immediate notification in the event of a spill of dairy water. District staff will request to accompany Regional Board inspectors in their rounds of dairies in the watershed so as to establish routine contact with dairy owners and operators.

- Pesticides and Fertilizer Application_As a preventive measure, the District is working with the City of Moreno Valley to reduce pesticide application rates and switch to non-water contaminating pesticides.

- Recreation_The District plans to:
    - Distribute information to educate the public about the connection between recreational activities and contamination of the drinking water supply.

    - Work with the City of Canyon Lake regarding the city's plans to lease areas in the vicinity of the reservoir. The intent should be to implement use restrictions to protect water quality and prohibit illegal activities.

- Water Quality Monitoring_The District is implementing a monitoring program to determine if activities in Canyon Lake (i.e., recreation, sewage system) or upstream of the reservoir (dairies, agriculture, septic systems, etc.) or both, are contributing significantly to the coliform, TOC, and nutrient levels at the intakes.

Watershed Management: The First Barrier in a Multi-Barrier Treatment Scheme at Lake Tahoe

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To assure high quality potable water, the 1986 Safe Drinking Water Act (SDWA) sets treatment requirements for surface water supplies focusing on microbiological contaminants. The Surface Water Treatment Rule (SWTR) sets specific Maximum Contaminant Level Goals (MCLGs) of zero for Giardia lamblia, enteric viruses and Legionellia, and requires filtration of all surface water systems unless source water quality can be assured through adoption of a watershed management plan and controlling watershed activities. In this context, watershed management in lieu of filtration is the first barrier of a multi-barrier protection system to provide inactivation of pathogens. The multi-barrier approach involves the use of source water quality protection, optimized water treatment, and distribution system integrity to provide safe drinking water.

The SWTR created a special challenge for the Lake Tahoe water purveyors who have historically relied on the lake as their water supply with only minimal chlorination before distribution to customers. The lake offers a pristine water supply, typically with turbidities in the range of 0.2 NTU. The public water purveyors, which generally have limited technical and financial resources, range from very small 0.13 mgd to 3.1 mgd in size. The challenge was to meet the SWTR watershed control requirements and gain an exemption from filtration of surface water while providing customers equivalent protection from pathogen contamination and remaining in compliance with proposed Disinfection By-Product (DBP) regulations. The Nevada State Health Division, Consumer Health Protection Services (NCHPS), introduced the concept of "level of protection equivalent to watershed control" into their final SWTR adopted 29 November 1990. A special provision states, "Alternatively for systems at Lake Tahoe, the suppliers of water shall demonstrate that by the location of the intake structure a level of protection equivalent to watershed control is provided." The concept of "equivalent control" allowed the water purveyors to pursue watershed management as a viable and cost-effective alternative to filtration to safeguard public water supply.

Tahoe Basin

Located east of the Sierra-Nevada divide, the Tahoe Basin (Basin) is bisected by the California/Nevada border. The basin covers an area of 506 square miles, of which 315 square miles are land surface area. Tahoe is the tenth deepest lake in the world with an average depth of 1,027 feet and a maximum depth of 1,645 feet. The lake has an exceptionally long average resident time of 700 years (Crippen, 1972). In addition, the lake's stratification/destratification and algal bloom potential remain low due to its extreme clarity, low nitrogen and phosphorus levels, low turbidities and color, and minimal chlorine demand. The lake does not mix vertically every year (Tahoe Regional Planning Agency (TRPA), 1994), which could help make it act as a sink for microbes. Whether organisms become inactivated by deactivation, biological processes, physical actions such as sedimentation, or a combination of the above is not clearly understood.

The Basin is 77.1 percent publicly owned and 22.9 percent privately owned, however, 66 percent of shore line is privately owned and 34 percent publicly owned. Development within the Basin occurs entirely on the low-lying gentle slopes near the lakeshore. The Basin is home for approximately 52,000 residents. It is, however, the influx of seasonal visitors with daily populations swelling to 250,000 during the summer months that imposes the greatest challenge to the resources and recreational facilities within the Basin.

Potential Sources of Pollution

Storm water runoff is a primary mechanism by which sediment, nutrient, and other pollutants are transported to tributary streams and to Lake Tahoe directly. Of ten sites monitored for surface discharge, approximately 80 percent violated TRPA and state standards for dissolved phosphorus (TRPA, 1994). Obviously, control of surface water quality will continue to be a principal objective of the regulatory agencies and, because of its potential impact on turbidities, a focus of the water purveyors utilizing Lake Tahoe as a raw water source.

Three wastewater treatment plants are located in the Basin, and all wastewater, either untreated (west shore) or treated (Nevada and South Lake Tahoe) is exported out of the Basin. There are 103 sewer pump stations and numerous kilometers of sewer collection piping. No operating landfills exist in the Basin, nor are there any known water quality problems created by the four known closed landfills. Existing regulations prohibit the disposal of solid (or liquid) waste within the Basin. Storm water runoff and water coming in contact with solid waste at the two transfer stations are pre-treated prior to discharge. No commercial feedlots or areas where large numbers of grazing animals congregate exist, although grazing still occurs within some meadows in the upper Truckee River area under three cattle-grazing allotments and two horse-grazing pastures, which account for approximately 400 animal units. Truck routes pass through the Basin, creating the potential for hazardous spills. In 1990, Nevada Division of Emergency Management reported eight spills in the Nevada portion, while the California Office of Emergency Services reported ten spills, mostly involving petroleum by-products. Septic tanks have been outlawed and most homes are connected to sewers. Collection system breaks can result in sewage flows into the watershed.

The scenic beauty and recreational opportunities at Lake Tahoe make the Basin a favorite tourist attraction. Recreational activities include boating, waterskiing, and related beach sports; cross-country and downhill skiing, snowmobiling, and related winter sports; camping; golf; off-road vehicles; horseback riding; and hiking. Vessel waste and potential contamination by boaters is a concern, with approximately 25 launching facilities, 580 single-use piers, 134 multi-use piers, and numerous mooring buoys. Approximately 6,000 boats can operate on Lake Tahoe on a peak summer weekend. There are 19 campground facilities containing about 2,000 campsites, and approximately 13 public beaches, allowing swimming and water sports, of which all but one have flush-toilet facilities. There are nine golf courses within the Basin, of which three are championship and the remainder either nine-hole or executive courses. TRPA has required golf courses to implement fertilizer and pesticide management plans to reduce contamination.

Water Quality Program

To demonstrate a level of protection equivalent to watershed control, the nine participating Nevada water purveyors undertook a year-long water quality monitoring program in 1991, sampling their ten intakes for (1) Total and Fecal Coliform: two to three times per week; (2) Turbidity: continuous, or every four hours; (3) Giardia and Cryptosporidium: twice a month; and (4) Enteric Viruses. All utilities participating in the effort have extended their monitoring programs indefinitely, as required by NCHPS and the California Department of Health Services. With over four years' microbial monitoring, the Nevada purveyors have consistently demonstrated total and fecal coliform levels well below 100 and 20 per 100 milliliters (ml), respectively; Giardia and Cryptosporidium levels well below a geometric mean of 1 cyst and oocyst per 100 liters (1/100L); and no enteric viruses. The average turbidity at each of the eleven intakes shows an overall raw water turbidity averaging in the range of 0.17 to 0.20 NTU. Clearly, turbidity variations are very slight and well below the 5.0 NTU turbidity limit established by SWTR.

The Tahoe Research Group evaluated the vertical distribution of heterotrophic bacteria in a lake water column. Depth profiles of viable and total bacteria count in relation to water temperature and relative light intensity were studied. Little bacterial accumulation in the hypolimnion was seen. Furthermore, no correlation was observed between bacterial density and water temperature. A decrease of bacterial density was found in both viable and total counts of the upper photic zone less than 24 m deep. This may be due to bacterial cellular damage caused by solar radiation. The inhibitory effect of sunlight is at least one of the reasons for a lower bacterial density in the upper epilimnion (Watanabe, 1984).

The numerical goal for Giardia and Cryptosporidium is less than 1/100L as a geometric mean. In the four-year plus monitoring period, eleven presumptive Giardia cysts and 158 presumptive Cryptosporidium oocysts were encountered. To put the microbial concentration in perspective, the reports for calendar years 1993 and 1994 were analyzed. In 1993, 31 protozoa were detected in a total sample volume of 129,358 1, indicating an average occurrence of 0.024 oocysts/100L. In 1994, those numbers were 15 oocysts and cysts (including two Giardia) in 178,921 1, yielding 0.0084 oocysts (and cysts) /100L. The maximum oocyst concentration detected was 1.95 oocysts/100L.

The Lake Tahoe utilities have also monitored total and fecal coliform. During the initial one-year monitoring period ending February 1992, only two of the ten Nevada purveyors had reported sampling events in excess of the SWTR limit. Edgewood Water Company showed only 1 percent of its sample in excess of 100 per 100 ml, while Round Hill General Improvement District had total coliform of 3 percent in excess of 100 per 100 ml and 2 percent of its fecal coliform above 20 per 100 ml. In over four years, not a single fecal coliform has been detected in Incline Village General Improvement District's two intakes, while total coliform generally average 0 or 1 per 100 ml. Edgewood Water Company has since installed a deep intake. Total trihalomethane (TTHM) formation potential for Lake Tahoe is very low. It reached 25.7 and 28.5 mg/l after 7 days for raw and ozonated water respectively.

Intake Design

In personal correspondence, Dr. Charles Goldman (1995), Director of the Tahoe Research Group, University of California, Davis, states that design, considering wind and lake currents, among other factors, can optimize turbidity levels, and, by doing so, minimize risks of microbial contamination of raw water supplies. Incline Village General Improvement District's comparative results between the existing raw water intake and the "deep water" site, 400 m (1,300 ft) off-shore in about 14 m (45 ft) of water, indicate an apparent buffering effect to turbidity events. Increases of turbidity coincident with high wind and/or high runoff events up to 1.26 NTU were observed at the existing intakes. Meanwhile, the deep water sampling location remained nearly constant within a range of 0.1 to 0.2 NTU. In three separate events where data exist at both the existing intake and deep water location, a spike of greater than 0.6 NTU at the existing intake was followed within two weeks with a spike exceeding 0.3 NTU at the deep location. In each case, the initial spike appeared to be meteorologically induced. These results support a conclusion that the deeper, more distant intake location dampens and delays the impact of weather related spikes on raw water quality. Intakes at depth of at least 30 ft of water have been recommended.

By June 1995, two of the original Nevada nine have constructed water disinfection plants utilizing ozone and have filtration exemptions, while the remaining six have time extensions for putting their new facilities on-line.

Best Management Practices

Implementation of best management practices (BMPs) is essential for watershed management (Robbins, 1991). BMPs include a slate of both structural and non-structural methods to minimize and mitigate potential contaminant sources. Non-structural means are favored over structural means with the inherent need for long-term financial obligations for construction and maintenance. Non-structural controls involving land use and regulations imposed by the TRPA, U.S. Forest Service, and other agencies have been effective and continuously reviewed. Fundamental to any BMP program is public involvement and education. To that end, there are numerous publications within the Basin aimed at property owners and visitors to sensitize those that enjoy the Basin as to the potential sources of contamination and means for control.

The watershed sanitary survey documents prepared by the water purveyors participating in filtration avoidance (HDR, 1992 and 1995) identify a number of significant BMPs, including (1) Microbial Controls: Extend the intake to a minimum depth of 9 m (30 feet), should water quality degrade at an existing raw water intake location; (2) Sediment and Nutrient Controls: Practice timber management and fuels abatement programs to reduce wildfire danger; utilize sedimentation basins, rock slope stabilization, and other slope stabilization methods including ground cover to reduce suspension and transport of soils in erosion-prone areas; (3) Sewer Systems: Routinely inspect wastewater pumping stations and perform preventive maintenance; construct overflow bypass lines and containment basins to capture accidental spills; routinely replace old and defective sewage pipes; maintain hygiene in and around public restrooms located in public parks; encourage city and county agencies to maintain active street and highway sweeping programs; encourage public agencies to require small boat owners to carry "porta-potties" on the lake and provide storage tanks for pump-out facilities at boat launches; (4) Hazardous Materials: Require frequent inspection and maintenance of solid waste pick-up transfer and disposal facilities; work with TRPA and state transportation departments to discourage transport of hazardous materials when other alternative routes outside the Basin are available, and maintain emergency contingency measure to address accidental releases or spills; (5) Education: Maintain an active public education program to disseminate vital information for the protection of lake water quality, public notices discouraging unauthorized disposal of refuse and sewage, and need for proper hygiene among boaters.

Conclusions

The physical and institutional characteristics of the Tahoe Basin, including existing regulatory controls, size, depth, residence time within Lake Tahoe, and watershed activities appear to provide a physical barrier preventing the introduction of microbial contaminants into the raw water supply for those purveyors with appropriately designed intakes. In this instance, water quality in Tahoe appears at least as high as that from a controlled watershed. Based on the monitoring results for microbial constituents, Giardia and Cryptosporidium concentrations are in the range found in controlled watersheds.

Watershed controls, such as those imposed by the TRPA Code of Ordinances, U.S. Forest Service practices, and other agencies with jurisdiction in the Basin, appear adequate to minimize the introduction of microbial contaminants and excessive turbidity to the water supply. Source control is the first barrier in a multiple-barrier treatment train. Public confidence in the water supply will be shaken if the source water quality is known to be contaminated.

Based on the ozonation pilot study, utilities utilizing ozone as a primary disinfectant will be able to meet the proposed Disinfection By-Product Rule (Phase II) with TTHMs less than 40 µg/l.

The participating water utilities should continue implementation of BMPs associated with the sanitary survey results, including a comprehensive public education program, surveillance of the watershed, optimization of the operation and maintenance of all water and wastewater facilities, and continuation of the capital program to reduce sediment transport and improve storm water runoff to the lake. The efficacy of BMPs in reducing potential contamination should be evaluated to assure cost-effective use of public funds.

All utilities participating in the filtration avoidance program in Lake Tahoe have demonstrated that their facilities exceed the requirements for filtration avoidance, and should continue monitoring for microbial contaminants. As some pathogens are difficult to analyze for, remove, and disinfect with conventional treatment methods, keeping them out of source water may be the only way of providing multiple-barrier treatment. As water quality of source water deteriorates, the cost for treatment goes up and can become prohibitive.

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A Watershed Management Plan: Steps to Protect Your Water Supply

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Water suppliers must meet more stringent requirements on public water supplies and as a result, they are looking beyond increased levels of treatment to protecting source water quality. The basic tenet of water supply engineering is to use and maintain the best quality source possible. Today's challenge is to accommodate the varied activities in a watershed without sacrificing water quality. A watershed management approach to providing high-quality water examines a system from the source watershed to final treatment. Watershed management is the first, and often most cost-effective, step to ensuring a safe and reliable public water supply.

Watershed management is a holistic approach defined by hydrologic boundaries, not political boundaries, and integrates water quality impacts from both point sources and nonpoint sources. Key objectives of watershed management plans include evaluating ability to meet treatment requirements, identifying potential contaminant sources, developing plans to improve water quality, and producing a beneficial watershed planning tool. Most land within a watershed is not owned and operated by one entity, therefore, an integral piece of a watershed approach also includes gaining consent among stakeholders with an interest in the watershed. A watershed management plan can enable water suppliers to control the quality of water to be treated, reduce treatment costs, gain public confidence in the water supply and reduce health risks by reducing the level of contaminants.

The State of California currently requires water systems that treat surface water supplies to perform watershed inventories. The proposed federal Enhanced Surface Water Treatment Rule may require water systems that treat surface water supplies to perform watershed inventories. Though not yet required, water systems are choosing to take the first step in implementing watershed management. Developing a watershed management plan typically includes the following steps:

Step 1 Establish Watershed Management Goals.

Step 2 Perform a Watershed Inventory.

Step 3 Conduct Contaminant Assessment.

Step 4 Develop Source Protection Strategies.

Step 5 Implement Watershed Management Plan.

Developing a Watershed Management Plan

In general, a watershed is a geographic area which drains to a water source, e.g., a river, a reservoir, or an aquifer. A watershed management plan identifies existing and potential sources of contamination in a watershed, defines the most appropriate mitigation strategies and outlines an implementation program.

The same steps to develop a management plan can be applied to most watersheds, however, differences in each watershed will guide the process. Watersheds can encompass a major metropolitan area, a pristine mountain valley or anything in-between. The number of stakeholders or agencies and individuals that own, control or operate land varies by watershed and they often have different ideas on what is most important in the watershed. The size of the watershed, or sub-watershed, the number of stakeholders, the diversity of land uses, and the level of detail desired will all play a part in determining the scope of a watershed management plan. The following steps provide the basic framework for developing a management plan for any watershed.

Step 1 Establish Watershed Management Goals

Once a water supplier or the responsible agencies have decided to develop a watershed management plan the first step is to establish goals. The goals provide guidance throughout the project by providing direction and answering the question, "What are we trying to accomplish?" Goals can relate to water quality protection, reservoir operations, cost considerations, regulatory requirements, and other land use considerations. Whatever the goals and objectives may be, it is useful to develop a primary goal statement and achievable objectives. The primary goal statement broadly states the intent of the management plan. The achievable objectives focus on specific solutions. Together these elements determine balanced qualitative or quantitative goals. The basic goals for a watershed will greatly affect the choice of management strategies.

The watershed goal statement developed by the Santa Clara Valley Water District in Northern California is a good example of a primary goal statement and objectives. The Santa Clara Valley Water District developed this goal statement for a Watershed Management Project:

"The goal of the Comprehensive Reservoir Watershed Management Project is to develop a reservoir watershed protection program to protect the water quality and supply reliability of the Santa Clara Valley Water District Reservoirs. To achieve this goal, the water district will seek to balance the watershed uses such as the rights of private property owners and public recreational activities with the protection and management of natural resources..."

Specific objectives defined to attain this goal include (1) preserve operational flexibility; (2) maintain water quality by minimizing pathogens, algal blooms and precursors to disinfection by products; and (3) minimize sediment loading (Santa Clara Valley Water District, 1994).

Step 2 Perform a Watershed Inventory

The purpose of a watershed inventory is to become familiar with the watershed and the problems that it faces (Robbins, 1991). Each watershed has its own characteristics and related water quality concerns. A community on the Front Range in Colorado may have a concern with high suspended solids coming down a mountain stream while a reservoir in Idaho may have algae problems resulting from irrigation return flows and wastewater effluent. A watershed inventory delineates the watershed boundary and examines the natural characteristics, land uses, and water quality within the watershed. These elements provide essential information for assessing existing and potential sources of contamination to a water supply.

The primary natural characteristics to investigate include topography, geology, climate, vegetation, hydrology, wildlife and land use. Relating terrain, soils, vegetation and hydrology, for example, is useful in evaluating runoff and erosion potential. Identifying native wildlife can indicate microbiological contamination. Knowing the natural characteristics also aids in developing appropriate management strategies later in the planning process.

Knowing the major land uses, land ownership, and population centers provides insight on the types of activities that are supported by the watershed. These factors relate both directly and indirectly to water quality impacts. Land use information can be ascertained from county and municipal general plans, regulatory agency files, agricultural and other existing reports, field surveys, and large federal landowners such as the Bureau of Reclamation, Forestry Service, and Park Service.

The purpose of developing a watershed management plan is to maintain a safe and reliable water supply, therefore, water quality is an integral portion of a plan. An inventory includes identifying and reviewing water quality monitoring data, focusing on key constituents of concern. The following constituents are typically of concern because they may impact public heath and affect treatment plant operations:

- Microbiological contaminants
- Turbidity

- Nutrients
- Natural organic matter
- Total dissolved solids
- Algae
- Organic contaminants
- Hardness
- Metals

The watershed inventory identifies the components of the watershed which can be integrated to evaluate the vulnerability of a water source.

Step 3 Conduct Contaminant Assessment

The contaminant assessment determines the vulnerability of the source water by identifying existing and potential pollutant sources and estimating impacts to water quality. Potential contaminant sources include both point and nonpoint sources such as:

- Wastewater discharges
- Urban runoff
- Agricultural crop land use
- Grazing
- Concentrated animal facilities
- Mine runoff
- Solid waste disposal facilities
- Recreational use
- Traffic accidents/spills

- Fires

The extent to which an activity may impact a water source can be evaluated by various methods which range in complexity. Evaluation methods may include physically-based modeling, empirical modeling, decision analysis, and best professional judgment. The best evaluation method selected should suit the available data, cost, and resources. Computer models are more complex and attempt to simulate the physical, chemical, and biological processes that affect contaminants. Models can handle a large amount of information to estimate the water quality impacts of different scenarios. Best professional judgment, on the other hand, is more simplistic and involves the evaluation of existing data by experienced professionals to determine the significance of existing and potential impacts and the best protection strategies to mitigate impacts. As an example, a pollutant impact matrix was developed for the City of Boulder, Colorado, to identify the level of concern for potential contaminants in its watersheds, an excerpt from this matrix is presented as Table 1. Rankings were based on criteria including the distance to the water supply, the distance to the treatment plant intake, the frequency and probability of contamination, type of contaminant and relative concentration of contaminant.

Table 1. Potential contaminant sources, impacts and actions (Brown and Caldwell, 1992).

Location	**Contaminant source**	**Contaminants of concern**	**Ranking-existing**	**Ranking-future**	**Basis**
Boulder Reservoir	Recreation	pathogens volatile organics	medium	medium	pathogen levels high seasonal occurrence
Dry Creek	Wastewater irrigation reuse and runoff	pathogens nutrients metals organic diss.solids	low		impervious surface limited return flows limited
Dry Creek	Local soils	sulfates sodium hardness	medium-low	medium-low	seasonally important (Nov. - Mar.) small loadings

Whatever the selected evaluation method, it should be appropriate for the purpose of the watershed management plan and the available data and resources. As an example, computer models are only as good as the input data and assumptions, therefore, if little data is available best professional judgment may be a more appropriate evaluation method.

Step 4 Develop Source Protection Strategies

Once the goals of the watershed management program have been determined, the watershed has been characterized and contaminant sources have been evaluated, the appropriate source protection strategies can be determined. Source protection strategies, or best management practices, are a means of mitigating contaminant sources. The source protection strategies should focus on key watershed activities and constituents of concern to protect water quality. Source protection approaches may include both non-structural and structural control strategies.

Non-structural controls utilize planning, regulatory policies, and land ownership to minimize threats to water quality. Structural controls include capital improvements designed to detain or divert contaminants in surface runoff. The Marin Municipal Water District (MMWD), located in Northern California, performed a watershed sanitary survey or watershed inventory to comply with the California Surface Water Treatment Rule. MMWD stores source water in two watersheds; MMWD owns and controls most of the Mount Tamalpais Watershed, but has little control over activities in the Nicasio Watershed. Selected non-structural control strategies identified and recommended in the watershed inventory include:

Mount Tamalpais Watershed

- Policy for Land Use and Management

- No livestock grazing

- Access control

Nicasio Watershed

- Development controls_parcels >60 acres in subwatershed

- Private landowner agreements

- Agricultural land trusts to purchase development rights

Typical examples of structural control strategies include wet retention ponds, dry detention ponds, infiltration controls and diversion systems. Non-structural controls focus on minimizing the sources of contaminants and are usually not costly to implement, but it can be difficult to quantify removal rates. Structural controls focus on removing contaminants that have entered runoff and removal efficiencies can be measured, but these controls require maintenance and can have high capital costs.

Step 5 Implement Watershed Management Plan

The maintenance or improvement of water quality from a management plan relies on how well the plan is implemented and monitored. Implementation requires ownership of the plan, financing, stakeholder involvement or consent, and long-term monitoring. The owner of a plan may be an advisory committee, a regional planning agency, water utility staff, or a consultant. The owner is responsible for acquiring staff and financial resources and disseminating information among internal and external stakeholders.

A long-term monitoring program is essential to the management plan as a means to review and evaluate progress. The plan is a dynamic process and goals should be revisited periodically to address changes in watershed activities, water quality and effectiveness of source protection strategies. Modifications in the plan may be necessary to address these changes.

Benefits of a Watershed Management Plan

Protecting water quality on a watershed basis can be cost effective by minimizing the need for extensive water treatment. Watershed control measures implemented in the Lake Tahoe Basin enabled water utilities to avoid filtration requirements and millions of dollars in added treatment costs. Most importantly, developing a watershed management plan is a proactive approach to protecting a water supply. This proactive approach aims to protect human health, the reliability of existing supplies, and the water quality of the entire watershed.

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A Workshop on a Technique for Assessing Stream Habitat Structure for Nonpoint-Source Evaluations

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Water resource managers face problems of understanding and managing nonpoint source pollution, evaluating the complex, cumulative impacts of changing land use on stream habitats and biological communities, and assessing the effectiveness of fish habitat improvement projects and other mitigation procedures (Frissell et al., 1986). The majority of water resource programs are oriented toward detection and monitoring of chemical contamination, and are deficient in detecting other forms of perturbation (Barbour and Stribling, 1994). However, it is generally recognized that the main stressor in nonpoint source impacts is alteration of the physical habitat structure. The principal objectives of the Clean Water Act are "to restore and maintain the chemical, physical and biological integrity of the Nation's waters" (section 101). In response to these mandates, methods to assess the integrity of our water resources have been developed and tested in a variety of stream types.

The quality of the instream and riparian habitat influences the structure and function of fish and macroinvertebrate assemblages in a stream. The effects of water quality on these faunal distributions is sometimes obscured by the presence of a degraded habitat. A comprehensive approach to assessing the quality of stream habitat structure should include an evaluation of habitat complexity, including the variety and quality of the substrate, channel morphology, bank structure, and riparian vegetation. Biological potential is limited by the quality of the structure of the habitat. Habitat assessment is becoming a critical tool in evaluating effects to the water resource from nonpoint sources. Barbour and Stribling (1991) modified the habitat assessment approach originally developed for Rapid Bioassessment Protocols (Plafkin et al., 1989) to include additional assessment metrics for high gradient streams (Figure 1) and a different metric set more appropriate for low gradient streams. These metrics relate to various components of the stream and riparian habitat and provide information that, when integrated, allow for the judgment of habitat quality relative to regionally-expected reference conditions. The ability to accurately assess the quality of the physical habitat structure using a visual-based approach depends on several factors:

- The metrics selected to represent the various features of habitat structure need to be relevant and clearly defined.
- A continuum of conditions for each metric must exist that can be characterized from the optimum for the region of the stream type under study to the poorest situation reflecting substantial alteration due to anthropogenic activities.
- The judgment criteria for the attributes of each metric should minimize the subjectivity through either quantitative measurements or specific categorical choices.
- The Investigators are experienced in or adequately trained for stream assessments in the region under study.
- Adequate documentation is maintained to evaluate and correct errors resulting in outliers and aberrant assessments.

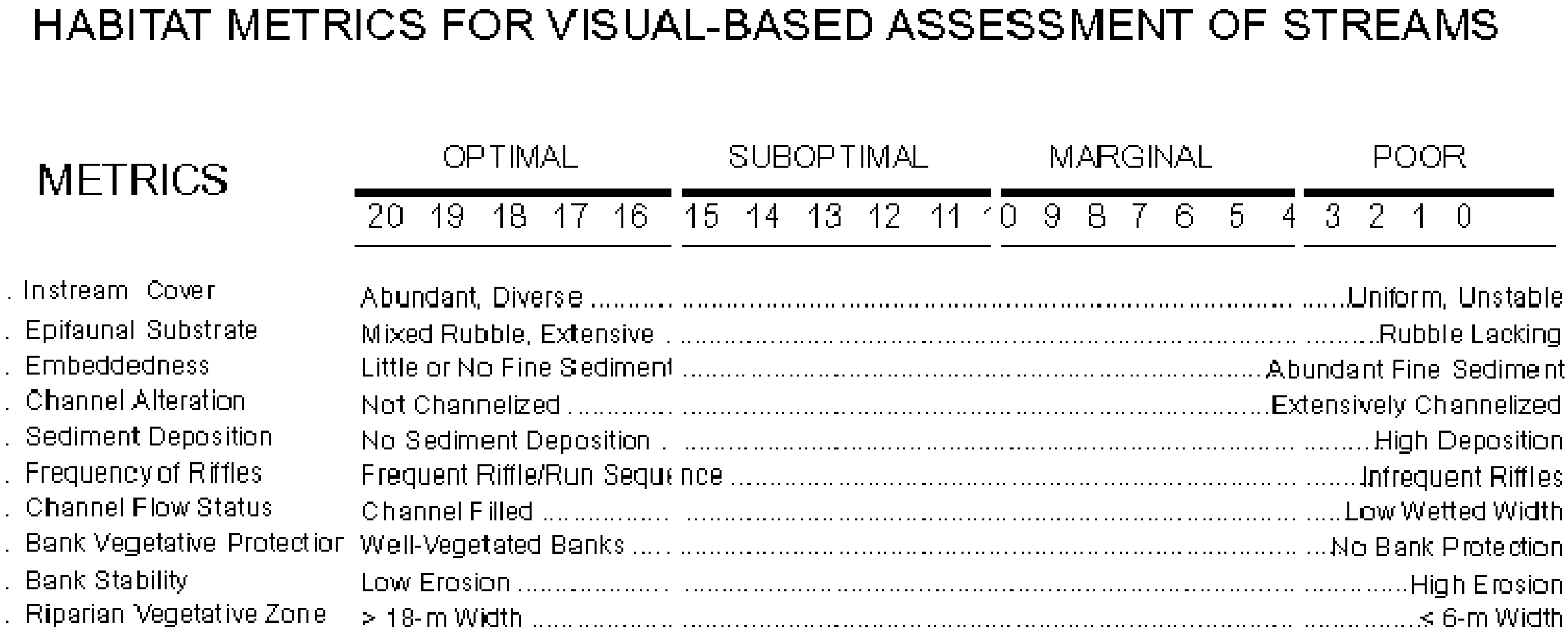

Figure 1.

Habitat Metrics for Assessment of High-gradient Streams

Instream Cover (fish) includes the relative quantity and variety of natural structures in the stream, such as fallen trees, logs, and branches, large rocks, and undercut banks, that are available as refugia, feeding, or sites for laying eggs. A wide variety and/or abundance of submerged structures in the stream provides the fish with a large number of niches, thus increasing the diversity. As variety and abundance of cover decreases, habitat structure becomes monotonous, fish diversity decreases, and the potential for recovery following disturbance decreases.

Epifaunal Substrate is essentially the microhabitat diversity of hard substrates (rocks, snags, etc.) available for insects, snails and other inverterbrates. Numerous types of insect larvae and nymphs attach themselves to rocks, logs, branches, or other submerged substrates. As with fish, the greater the variety and extent of available microhabitats or attachment sites, the greater the variety of insects in the stream. Rocky-bottom areas are critical for maintaining a variety of insects in most high-gradient streams. Snags and submerged logs are among the most productive habitat structure in low-gradient streams.

Embeddedness refers to the extent to which rocks (gravel, cobble, and boulders) are covered or sunken into the silt, sand, or mud of the stream bottom. Generally, as rocks become embedded, the surface area available to macroinvertebrates and fish (shelter, spawning, and egg incubation) is decreased. Embeddedness is a result of large-scale sediment movement and deposition, and is a parameter evaluated in the riffles and runs of high-gradient streams.

Channel Alteration is a measure of large-scale changes in the shape of the stream channel. Many streams in urban and agricultural areas have been straightened, deepened, or diverted into concrete channels, often for flood control purposes. Such streams have reductions in natural habitats for fish, macroinvertebrates, and plants than do naturally meandering streams. Channel alteration is present when artificial embankments, riprap, and other forms of artificial bank stabilization or structures are present; when the stream is very straight for significant distances; when dams and bridges are present; and when other such changes have occurred. Scouring is often associated with channel alteration in particular, downstream of channelized reaches.

Sediment Deposition measures the amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result of deposition. Deposition occurs from large-scale movement of sediment. Sediment deposition may cause the formation of islands, point bars (areas of increased deposition usually at the beginning of a meander that increase in size as the channel is diverted toward the outer bank) or shoals, or result in the filling of pools. Heavy sedimet deposition can cause erosive flow energy to be diverted into streambanks, causing instability. It can also be evident in areas that are obstructed by natural or manmade debris and areas where the stream flow decreases, such as bends. High levels of sediment deposition create an unstable and continually changing environment that becomes unsuitable for many organisms.

Frequency of Riffles (or bends)/Velocity Depth Combinations is a way to measure the sequence of riffles and, in part, the complexity of habitat occurring in a stream. Riffles are a source of high-quality habitat and diverse fauna; therefore, an increased frequency of riffle occurrence usually enhances the diversity of the stream benthic community. For areas where distinct riffles are uncommon, a run/bend ratio can be used as a measure of one characteristic of channel meandering or sinuosity. High sinuosity provides for diverse habitat and fauna, and the stream is better able to handle flow surges when the stream fluctuates as a result of storms. The absorption of this energy by bends protects the stream from excessive erosion and flooding. In headwaters, riffles are usually continuous and the presence of cascades or boulders provides a verticle sinuosity and enhances the complexity of the stream habitat structure. In "oxbow" streams of coastal areas and deltas, meanders are highly exaggerated and transient. Natural conditions in these streams are shifting channels and bends, and alteration is usually in the form of flow regulation and diversion. A stable channel is one that does not exhibit progressive changes in slope, shape, or dimensions, although short-term variations may occur during floods (Gordon et al., 1992). Patterns of velocity and depth are included under this parameter. The best streams in high-gradient regions will have all four patterns present: (1) slow-deep; (2) slow-shallow; (3) fast-deep; and (4) fast-shallow. The general guidelines are 0.5 meter depth to separate shallow from deep, and 0.3 meter/sec to separate fast from slow. The occurrence of these four patterns relates to the capacity of the stream structure to provide and maintain a stable aquatic environment.

Channel Flow Status is the degree to which the channel is filled with water. The flow status will change as the channel enlarges (e.g., aggrading stream beds with actively widening channels) or as flow decreases as result of dams and other obstructions, diversions for irrigation, or drought. When water does not cover much of the streambed, the amount of viable substrate for aquatic organisms is limited. In high-gradient streams, riffles and cobble substrate are exposed; in low-gradient streams, the decrease in water level exposes logs and snags, thereby reducing the areas of good habitat. Channel flow status is severely reduced in low gradient streams that have becomre braided. This metric is especially useful for interpreting biological condition under abnormal or lowered flow conditions.

Bank Vegetative Protection measures the amount of the stream bank that is covered by vegetation. The root systems of plants growing on stream banks help hold soil in place, thereby reducing the amount of erosion that is likely to occur. This parameter supplies information on the ability of the bank to resist erosion as well as some additional information on the uptake of nutrients by the plants, the control of instream scouring, and stream shading. Banks that have full, natural plant growth are better for fish and macroinvertebrates than are banks without vegetative protection or those shored up with concrete or riprap. This parameter is made more effective by defining the natural vegetation for the region and stream type (i.e., shrubs, trees, etc.). In areas of high grazing pressure from livestock or where residential and urban development activities disrupt the riparian zone, the growth of a natural plant community is impeded. Residential developments, urban centers, golf courses, logging, and pastureland are the common anthropogenic causes of riparian zone degradation .

Bank Stability (condition of banks) measures whether the stream banks are eroded (or have the potential for erosion). Steep banks are more likely to collapse and suffer from erosion than are gently sloping banks, and are therefore considered to be unstable. Signs of erosion include crumbling, unvegetated banks, exposed tree roots, and exposed soil. Eroded banks indicate a problem of sediment movement and deposition, and suggest a scarcity of cover and organic input to streams.

Riparian Vegetative Zone Width measures the width of natural vegetation from the edge of the stream bank out through the riparian zone. The vegetative zone serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat and nutrient input into the stream. A relatively undisturbed riparian zone supports a robust stream system; narrow riparian zones occur when roads, parking lots, fields, lawns, bare soil, rocks, or buildings are near the stream bank. The presence of "old field" (i.e., an agricultural field not currently in production and supporting early-successional plant growth), paths, and walkways in an otherwise undisturbed riparian zone, may be judged to be inconsequential to impairment of the riparian zone. In some regions of the country, an increase in the specified width of a desirable riparian zone is warranted.

Conclusion

As with any environmental data collection and interpretation methods, physical habitat quality assessment approaches should take into account regional patterns and site-specific uniqueness. Regionally, it is recognized that gradient or slope is the most influential hydrologic-controlling factor of stream and habitat formation. The approach presented here addresses regional slope patterns by having different suites of parameters for high gradient and low gradient streams. Site-specific variability is addressed in two ways. First, because the complexity of stream habitat structure is recognized as a factor influencing (and resulting from) channel stability, generally higher rating scores are given to a complex stream. Second, if a stream has some feature that is different or unique from other streams in the region, individual parameters will score differently.

This paper presents a summary of the physical instream and riparian habitat features of a visual-based habitat assessment and their relationship to, and influence on, biological communities. The quality and stability of stream and riparian physical habitat, rated as it relates to unimpaired streams of similar site-specific and regional characteristics, provides an estimate of the biological potential of a stream system. The most important characteristic of a field biologist using this approach is that they possess training and experience in field stream ecology and are generally familiar with regional variability of streams in their region.

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The Response of Stream Macroinvertebrates and Water Quality to Varying Degrees of Watershed Suburbanization in Northern Virginia

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Introduction

Suburban development is becoming a predominant land use in many watersheds near large population centers. The conversion of watersheds with low population densities and land use intensities to suburban and urban land uses typically results in degradation of stream biotic communities. Possible factors responsible for degradation of stream communities include altered water quality, hydrology and habitat.

Numerous constituents of urban nonpoint source pollution may have deleterious or undesirable effects on freshwater macroinvertebrates. Suspended sediments interfere with respiration and feeding of stream invertebrates and when deposited bury desirable habitats through embedding. Increased levels of toxic contaminants such as heavy metals, road de-icing salts, petroleum hydrocarbons, and pesticides found in urban runoff may also have a deleterious effect (Jones and Holmes 1985). Although less important in flowing waters than in lakes and ponds, nitrogen and phosphorus can stimulate the growth of nuisance algae which may alter stream food webs. Temperature is a critical factor controlling the life cycles of many aquatic insects (Vannote and Sweeney 1980). Urbanization alters the temperature regime of streams by decreasing riparian vegetation and base flow, which could lead to the elimination of insects adapted to cooler pre-development conditions.

Given the potential for urban nonpoint pollutants to impact freshwater life, it is not surprising to find that most watershed studies to date indicate substantial degradation of the fauna of urban and suburban streams. Jones and Clark (1987) found that watershed suburbanization had a major impact on benthic insect communities even in the absence of point source discharges. Watershed development had little impact on total insect numbers, but shifted the taxonomic composition markedly. Chironomids increased while mayflies, stoneflies, beetles, and dobsonflies decreased.

The research described in this paper was conducted to support development of an innovative storm water management plan that demonstrates a watershed approach to natural resource conservation and sustainable development. This comparative study of three watersheds of varying land use histories is being conducted in the rapidly developing suburbs of Washington, D.C. Objectives of the study are to assess the status of biotic communities and water quality in the three watersheds and to assess the efficacy of individual best management practices.

Study Site

Located in eastern Prince William County, Virginia, the three watersheds are roughly parallel to one another and perpendicular to the tidal Potomac River into which they each drain. Each watershed originates in and is centered on the Piedmont physiographic province and all sampling stations are located within the Piedmont or at the Piedmont-Coastal Plain border. Neabsco Creek is a predominantly suburbanized watershed with single family (<1 acre lots) housing accounting for about 40% of the watershed. Other developed land such as commercial, highways, and other housing account for about 10% and the other 50% is open space consisting of parks, school sites, flood plains, and land zoned for development, but currently fallow. Powells Creek is predominantly open space (77%), with the remainder in low density housing. Quantico Creek is composed almost entirely of park and military reservation land. There are isolated dwellings scattered along roads in the upper headwaters. Subwatersheds sampled with bioassessment within each watershed drained 0.2-15.7 km2 in Neabsco (34 sites), 6.2-21.0 km2 in Powells (8 sites), and 0.2-43.6 km2 in Quantico (19 sites). Intensive water quality surveys involving both grab samples of base flow and automated sampling of storm flows have been conducted at selected sites within the watersheds.

Methods

A modification of the EPA Rapid Bioassessment Protocol (RBP) II was used as the basic tool for macroinvertebrate bioassessment (Plafkin et al. 1989). RBP II utilizes semiquantitative field collections in representative stream habitats to determine the values of up to eight metrics which characterize the status of the benthic macroinvertebrate community. Macroinvertebrate samples were collected at each station using a 44 cm x 22 cm pole-mounted kick net with a mesh size of 0.5 mm. The net was held to the stream bottom while a one meter strip of substrate directly upstream of the net was agitated for one minute. Two samples were collected at each station, one from a riffle and one from a run, and these were pooled to form a single composite sample. Where possible, a coarse particulate organic matter (CPOM) sample was collected, but these data are not included as many stations were lacking in CPOM. All macroinvertebrate samples were preserved in formalin. During the RBP sampling measurements of temperature, dissolved oxygen, conductivity, and pH were made using field probes.

In the lab samples were rinsed with tap water through a 0.5 mm sieve to remove formalin and placed into a 35 cm x 40 cm pan marked with 5 cm x 5 cm squares. After distributing the sample evenly over the pan, squares were selected from a random number table and organisms recovered until a total of 200 was reached or until the whole sample was sorted. The selected organisms were sorted into ethanol-glycerine, identified to family and enumerated.

Macroinvertebrate rating was calculated following the guidance of the EPA bioassessment manual (Plafkin et al. 1989). Two of the suggested metrics (scraper: filter collector ratio and shredders: total ratio) were not utilized. The former has not shown diagnostic value in our studies (Jones and Kelso 1994), while the latter requires a CPOM sample which was not available at all sites. We used Sorensen's index of community similarity instead of the community loss index. The other five metrics cited in the RBP II were utilized as outlined in the bioassessment manual. RBP results from three samplings (two in spring and one in fall) were included in this paper.

Intensive water quality measurements were made at several sites along Cow Branch, a Neabsco tributary, above and below a regional storm water facility. Grab samples were collected on a monthly to bimonthly basis and several storms were sampled using grab or automated sampling procedures. Samples were analyzed for a full suite of parameters including nutrients, metals, and major cations and anions.

Results and Discussion

Bioassessment results indicated that macroinvertebrate communities were least impacted in the undeveloped Quantico watershed and most impacted in the suburbanized Neabsco watershed (Table 1). Family richness, EPT/chironomid ratio, and EPT index averaged substantially higher in Quantico than Neabsco, although there was some overlap in all three metrics. Family biotic index and percent dominant taxon were highest in Neabsco, again indicating

Table 1. Results of RBP sampling. Averages over all stations with range shown in parentheses.

	Neabsco	Powells	Quantico
Family Richness	7.7 (1-21)	13 (8-21)	15 (8-23)
Family Biotic Index	5.4 (3.3-9.0)	4.7 (3.8-5.7)	4.4 (3.0-5.6)

greater impairment. Sorensen's index of similarity to the reference site averaged highest in Quantico. For 5 of the 6 metrics the lightly developed Powells Creek stations showed intermediate values. The exception was EPT/chironomid ratio which was the most variable metric. When the values of all six metrics were combined (RBP Composite Index), a clear trend emerged of increasing impairment of the macroinvertebrate community with increasing watershed suburbanization.

Water quality measurements made at the time of RBP sampling indicated minimal difference in base flow conditions among the three watersheds for the small suite of parameters measured. Temperatures did not exceed 26oC at any site. Dissolved oxygen readings below 5 mg/L were observed sporadically in both Neabsco and Quantico. pH readings were slightly acidic and even dropped below 5 in a few samples, again in both Neabsco and Quantico. Specific conductance was generally slightly lower at Quantico sites; however, a very high reading was also obtained at Quantico. Slightly acidic surface waters are typical of this area with more acidic conditions often associated with localized areas of pyrite oxidation.

Intensive water quality determinations were made on base flow and storm flow samples from sites above and below a regional storm water management pond in Cow Branch, a Neabsco tributary (Table 2). Two tributaries to the regional pond were sampled: PPUL and PPUR.

EPT/Chironomids (by abundance)	1.9 (0-41)	6.1 (0-47)	3.6 (0-88)
% Dominant Taxon	59.5 (22.2-100)	54.3 (22.6-85.5)	48.0 (18.4-86.4)
EPT Index	1.3 (0-5)	3.9 (1-6)	6.6 (2-12)
Sorenson's Index of Similarity to Ref	0.37 (0.09-0.63)	0.51 (0.33-0.71)	0.62 (0.35-1.00)
RBP Composite Index (6-metric)	9.1 (0-21)	16.2 (9-27)	20.4 (6-36)
% reference RBP Index	26.1 (0-63.6)	46.3 (27-83)	58.3 (18-100)
Temperature (C)	18.7 (9.1-25.7)	19.1 (7.9-22.9)	17.2 (4.9-24.2)
Dissolved oxygen (mg/L)	7.4 (3.1-10.9)	6.9 (5.2-9.9)	6.7 (2.8-13)
Dissolved oxygen (mg/L)	7.4 (3.1-10.9)	6.9 (5.2-9.9)	6.7 (2.8-13)
Dissolved oxygen (% saturation)	78.9 (35-95)	73.4 (60-95)	79.0 (31-101)
pH (field)	6.3 (4.9-6.8)	6.3 (6.0-6.5)	5.9 (4.6-6.9)
Conductivity (uS/cm)	119 (44-179)	126 (78-176)	70 (24-608)

PPUL and PPUR are permanent streams each draining about 0.5 km2. Land use is similar with about 20% developed as commercial or highway and the rest as mostly forested large lots or open space.

Average base and storm flows were similar. However, the two larger tributaries differed markedly in ionic content at base flow. PPUR exhibited markedly higher concentrations of some dissolved phase parameters like alkalinity, calcium, sulfate, ammonia-N, dissolved iron and dissolved manganese than PPUL. PPUL recorded higher levels of suspended solids (TSS), total kjeldahl nitrogen (TKN), nitrate-N, and total phosphorus. This watershed lies on the boundary between the Piedmont and Coastal Plain and soils and rock formations from these two areas are interwoven. The increased iron and manganese levels are related to leaching of these elements from crystalline rocks of the Piedmont (Robbins and Norden 1995). The enhanced calcium levels may result from leaching of scattered shell deposits in coastal plain soils. The differences in nutrient levels more likely result from differences in human activities in the two watersheds. At storm flow, differences in dissolved constituents were lessened while those in particulate parameters such as TSS and total phosphorus were enhanced. Land disturbance activities appeared to be more recent at PPUL which may explain the higher particulate values. Bioassessment data for PPUL and PPUR indicated little consistent difference with both streams exhibiting moderate impairment.

Two stations were located on Cow Branch downstream of the regional pond: PPD1, immediately downstream, and PPD5, approximately 1 km downstream. PPD1 exhibited characteristics that were generally intermediate to those observed at the inflow stations. Certain parameters such as ammonia-N, nitrite-N, nitrate-N, TKN, total suspended solids, and total phosphorus were obviously altered by residence in the pond. Ammonia-N, nitrite-N, and TKN showed increases while nitrate-N, TSS, and total phosphorus decreased below the pond. Between PPD1 and PPD5 large volumes of storm water were discharged directly into the stream resulting in large increases in storm concentrations of TSS and a slight increase in total phosphorus. Base flow concentrations of iron and manganese were greatly elevated at these sites and deposits of iron minerals were obvious. Biological data indicated moderate impairment immediately below the regional pond, but severe impairment below the large storm water inputs.

Table 2. Intensive water quality sampling at stations on the Cow Branch of Neabsco Cr.

Parameter		PPUL	PPUR	PPD1	PPD5
Discharge (cfs)	Base	0.15	0.22	--	0.40
	Storm	2.90	2.69	--	18.3
Conductivity (uS/cm)	Base	159	258	176	182
	Storm	107	97	87	59
pH	Base	6.96	6.59	6.86	6.52
	Storm	7.38	6.82	7.20	6.34
DO (mg/L)	Base	9.2	8.6	7.2	9.2
	Storm	9.0	8.6	--	8.8
Alkalinity (mg/L CaCO3)	Base	19.5	83.0	26.2	24.0
	Storm	12.0	20.3	17.0	7.8
TSS	Base	8.5	5.0	10.7	20.6
	Storm	570	45	34	3074
Ca++ (mg/L)	Base	8.7	30.3	9.3	12.5
	Storm	5.1	8.5	6.2	4.2

Conclusions

Macroinvertebrate bioassessment indicated substantial impairment of streams in the heavily suburbanized Neabsco Creek watershed relative to a companion forested watershed (Quantico Creek). A lightly developed adjacent watershed (Powells Creek) showed an intermediate level of impairment. All six metrics employed to assess the macroinvertebrate community exhibited a similar pattern. Field water quality measurements failed to detect any substantial differences among multiple sites in the three watersheds. Intensive water quality sampling of tributaries to a regional storm water management pond indicated considerable differences which did not result in obvious changes in the macroinvertebrate community. A site immediately below the pond exhibited alterations in nitrogen speciation and reduced suspended solids and total phosphorus levels, but little change in bioassessment metrics. Severe impairment of the benthic macroinvertebrate community was found further downstream below the discharge of large quantities of unmitigated storm water. Further study will be required to determine the extent to which the impacts of suburbanization in these watersheds can be ascribed to water quality impacts as opposed to other factors such as habitat modification.

SO_4^{-2} (mg/L)	Base	6.8	11.6	5.0	14.4
	Storm	7.9	5.0	4.9	6.5
NH_4-N (mg/L)	Base	0.07	0.26	0.42	0.20
	Storm	0.31	0.62	0.05	0.24
TKN	Base	0.80	0.47	0.90	0.43
	Storm	1.72	1.14	0.60	0.71
NO_2-N	Base	0.03	0.05	0.37	0.02
	Storm	0.03	0.04	0.05	0.02
NO_2 + NO_3-N (mg/L)	Base	0.53	0.25	0.23	0.36
	Storm	0.61	0.54	0.18	0.40
Total P (mg/L)	Base	0.13	0.02	0.03	0.03
	Storm	0.45	0.09	0.07	0.11
SRP	Base	0.01	nd	nd	0.02
	Storm	0.01	0.03	--	0.01
Dissolved Fe (ug/L)	Base	158	1690	1037	3414
	Storm	194	626	330	356
Dissolved Mn (ug/L)	Base	215	697	226	1043
	Storm	76	110	47	134

Acknowledgements

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Determining Ecological Quality Within a Watershed

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Watershed managers and engineers frequently rely on ambient EPA or state water quality criteria to determine overall water quality and to prioritize reaches in need of further examination or remediation. While this approach is relatively inexpensive to implement and requires little effort or expertise to obtain and interpret data, the underlying assumptions of this approach are often invalid. Physical habitat quality, pollutant bioavailability, and the type of animal and plant communities naturally present, are a few of the site-specific factors that often confound supposed relationships between pollutant concentrations and ecological effects in aquatic systems. These factors are often poorly understood or ignored in current watershed management approaches. Biological approaches to this problem are necessary because it is the biota and general ecology of the watershed that we are typically interested in protecting. This paper presents two case study examples in which relatively low-cost biological analyses were used to effectively determine the ecological quality of the watershed and where management resources should be spent.

Biological Assessments

In this first example, the upper Smith River, Virginia, was believed to be impaired because copper and cadmium concentrations instream were higher than state water quality standards. Point-source dischargers were implicated as the cause of elevated metal concentrations. These metals were thought to have potentially deleterious effects on aquatic life in Smith River and on the sport fishery downstream in Philpott Reservoir. Benthic macroinvertebrate and fish biological assessments of this watershed, using both a targeted and probabilistic sampling design, indicated little or no effects due to point-source discharges and also indicated generally unimpaired conditions at most locations compared to reference sites in the area (Figure 1). However, the bioassessments revealed certain habitat-poor areas due to livestock watering and other deleterious farming practices. Increased silt loading and fecal coliform were observed downstream of these areas resulting in poor spawning habitat for the stocked kokhanee rainbow trout in the reservoir. Thus, elevated metal concentrations in this watershed appeared to have little or no ecological impact. On the contrary, biological approaches demonstrated that higher management priority should be given to mitigating and preventing habitat destruction in the riparian zone and instream.

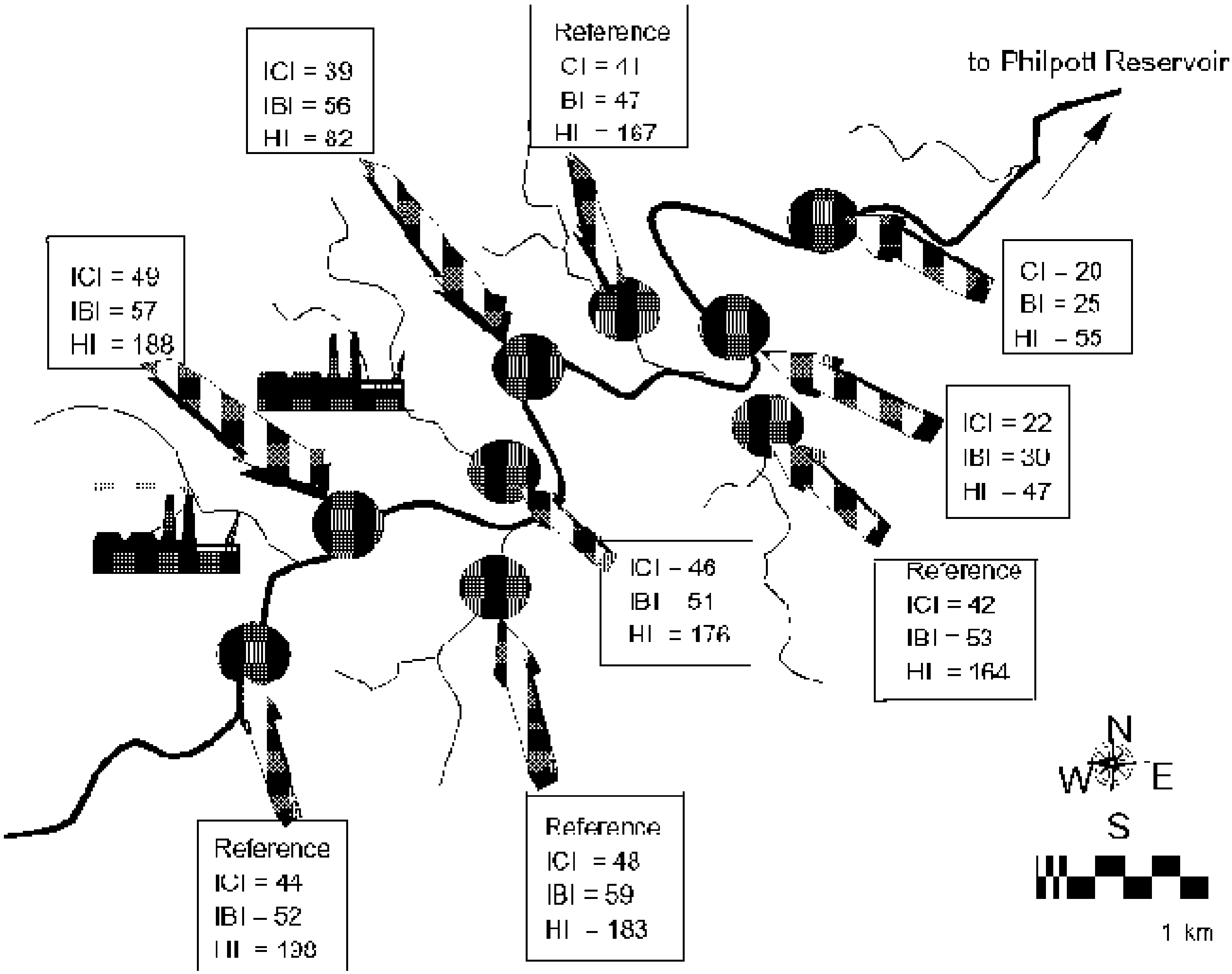


Figure 1. Assessment sites, invertebrate(ICI), fish (IBI) and habitat (HI) quality in upper Smith River, VA. Lower scores signify impairment.

In-Situ Bioassays, Ambient Water Testing, and Toxicity Identification Analyses

Biological techniques can not only help prioritize watershed areas in need of remediation, as indicated in the above example. They can also help define causes of impairment as illustrated in this second example involving a study of Peak Creek watershed, a tributary to Claytor Lake and the New River, Virginia (Figure 2). Benthic macroinvertebrate and fish biological assessments of this watershed, using a probabilistic and targeted sampling design, indicated ecological impairment in the town of Pulaski and downstream of an abandoned chemical manufacturing facility.

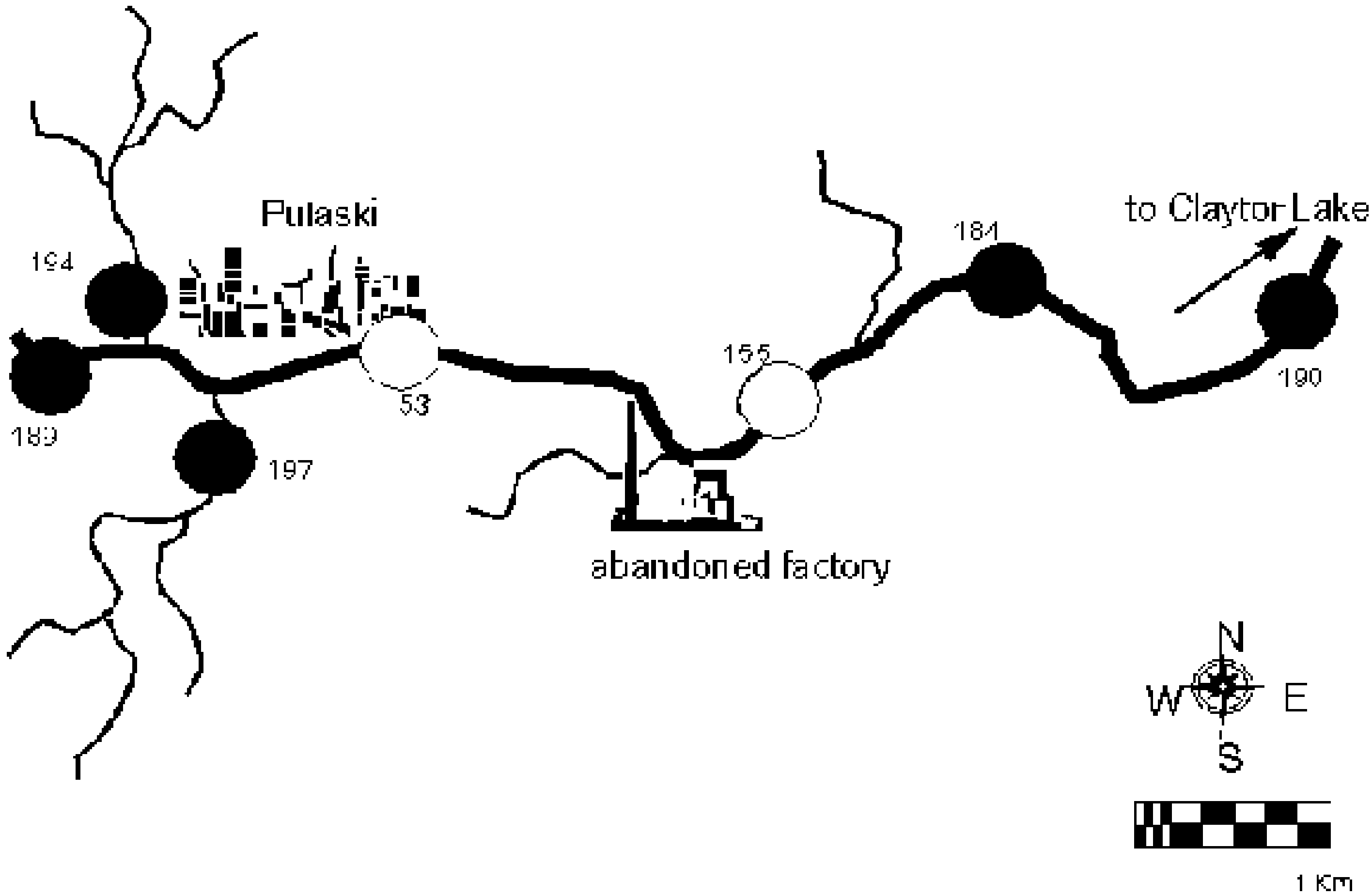


Figure 2. Assessment sites in Peak Creek, VA. showing habitat scores (numbers) and impaired sites (light shaded circles).

In-situ bioassays, using three ecologically important indigenous species, showed little or no acute or sub-acute toxicity effects at impaired sites during dry weather conditions (Figure 3). However, significant effects were evident during or after wet weather events downstream of the chemical facility only (Figure 3). Both habitat assessment data and results of in-situ bioassays suggested that the Pulaski site was impaired by poor riparian habitat and channel alteration whereas the abandoned factory site was impaired by toxic storm water runoff. Toxicity identification fractionation of the storm water runoff from the factory site implicated heavy metals as the chief cause of toxicity (Figure 4).

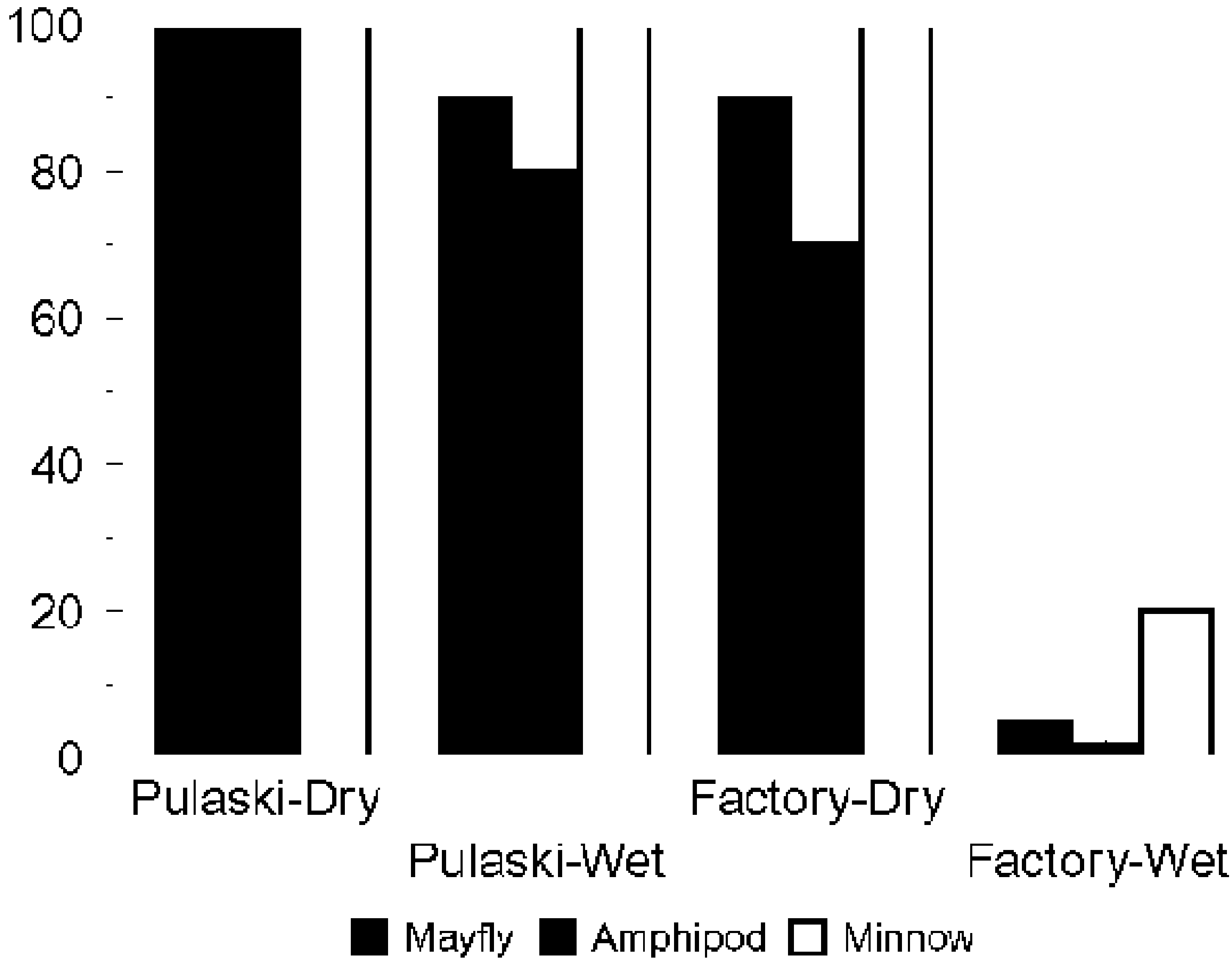
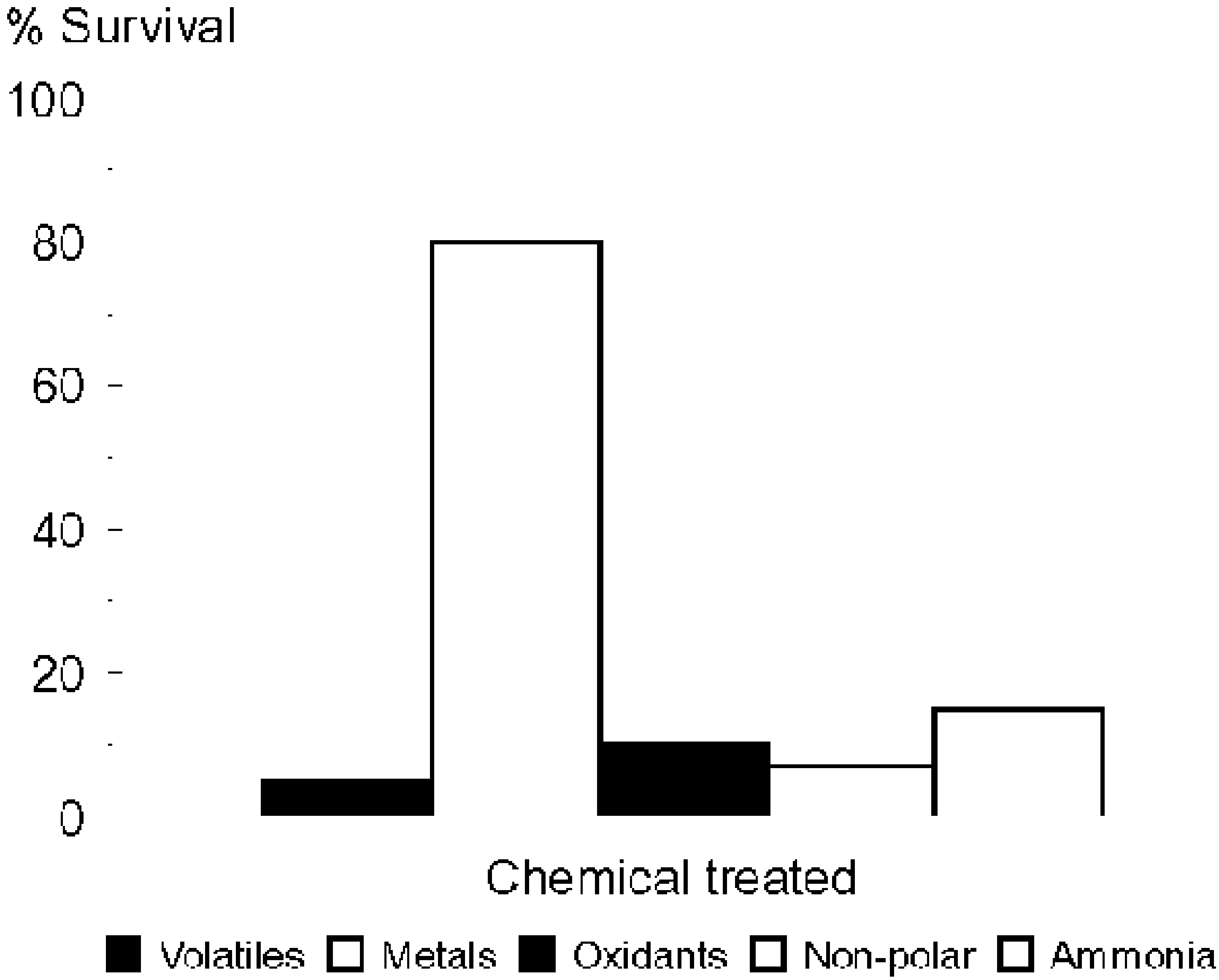


Figure 3. Percent survival of indigenous species in in-situ bioassays in Peak Creek during dry and wet weather near Pulaski and at an abandoned factory.



Figurre 4. *Ceriodaphnia* survival in differently treated fractions of storm water collected downstream of the factory site.

Simulated stream microcosm testing, using ambient water samples collected downstream from the facility, confirmed that storm water runoff from the factory site was toxic to sensitive indigenous invertebrates (Figure 5) and inhibited important functional ecological processes. Furthermore, the pulsed effect of storm water-derived metals entering Peak Creek was sufficient to cause significant impairment to aquatic life.

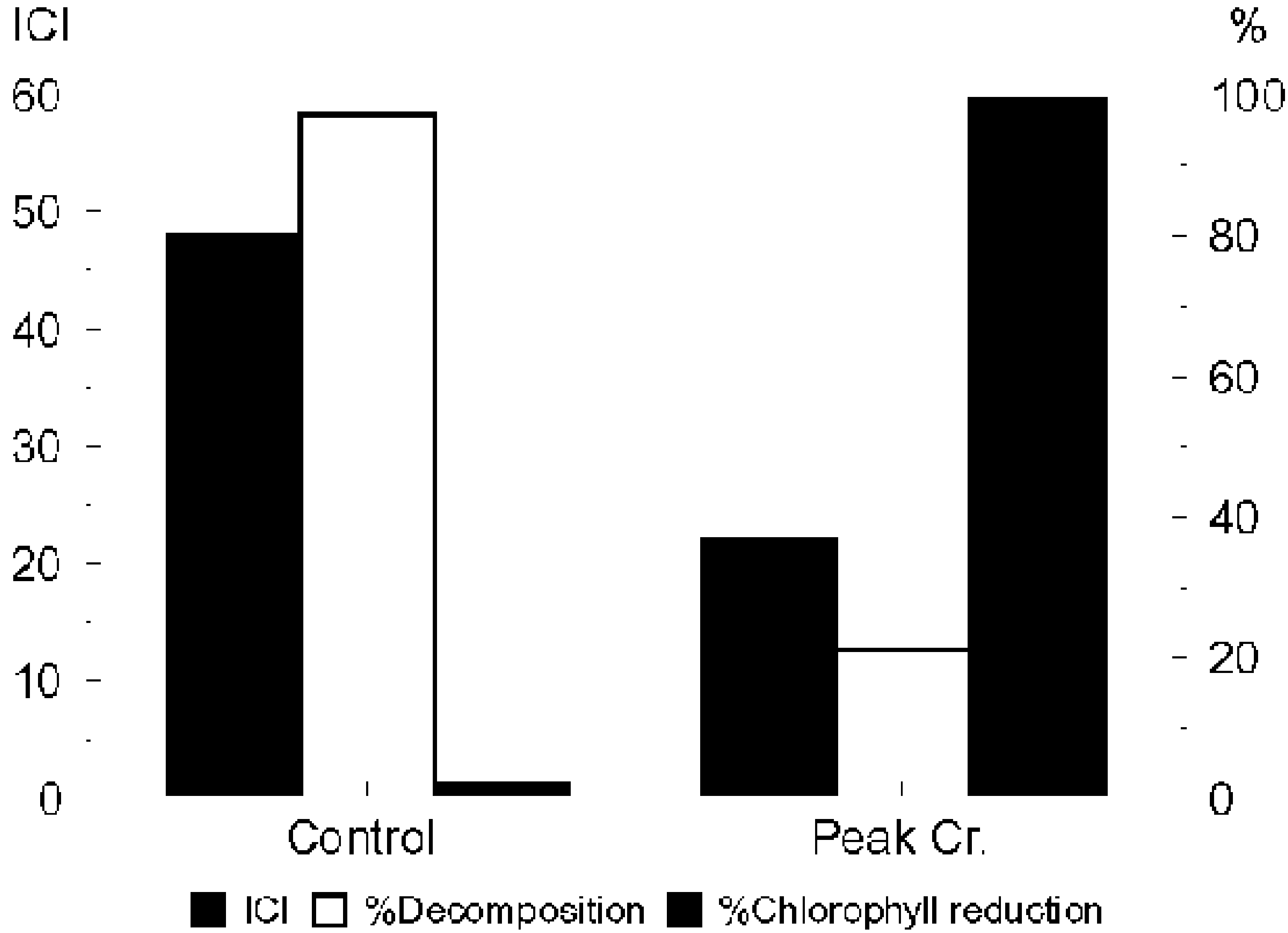


Figure 5. Results of simulated stream invertebrate microcosm study of pulsed Peak Creek storm water.

Subsequent metal analyses revealed high storm water copper concentrations downstream of the abandoned factory site and high sediment concentrations as well (Figure 6). The sediment was a probable source of copper and other metal pollutants during high flow events when benthic turbulence and resuspension of contaminants was highest. This process was probably affecting several kilometers of stream habitat and potentially, the lake.

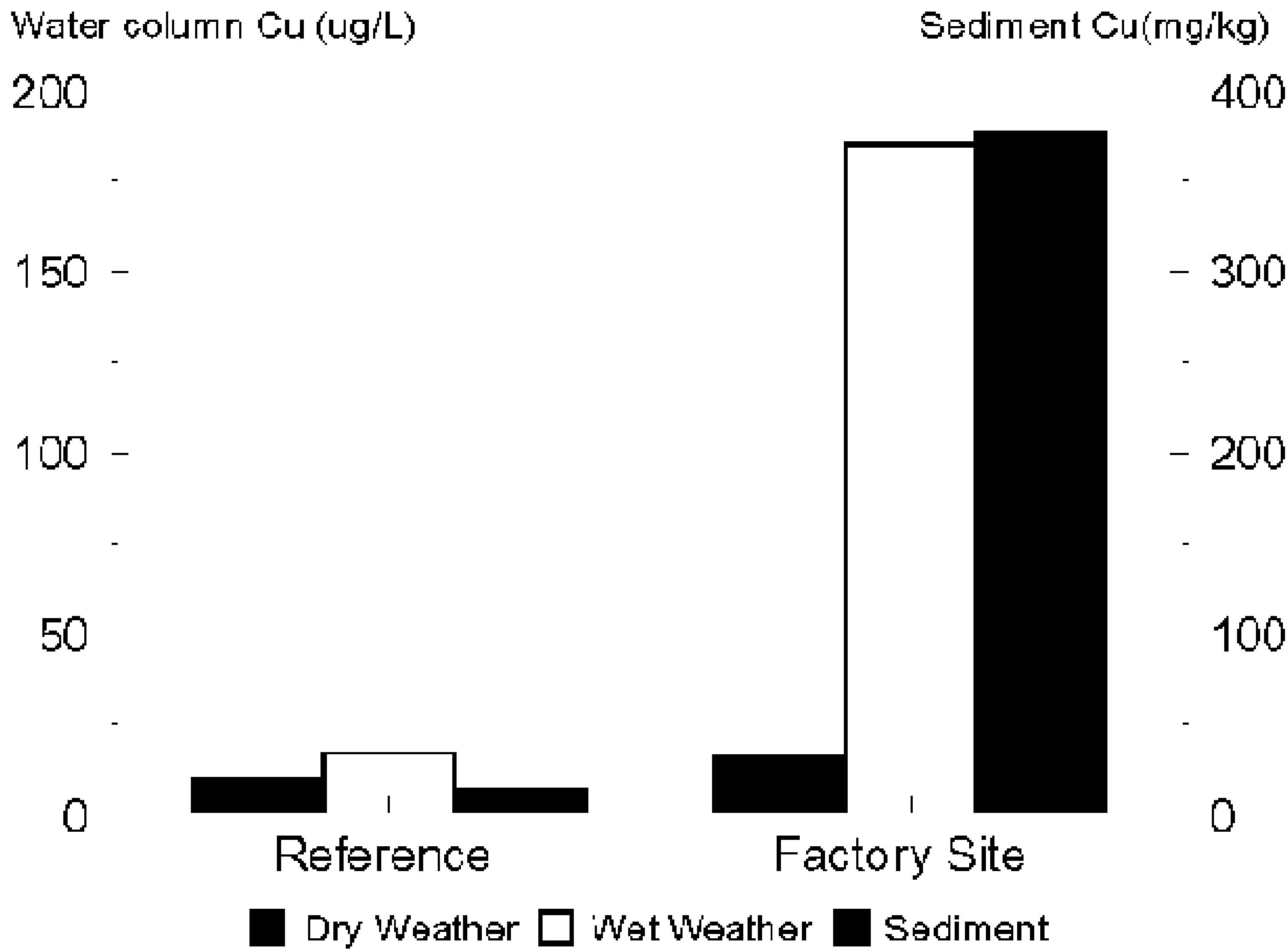


Figure 6. Sediment and wet and dry weather water column copper concentrations in Peak Creek.

Typical water quality chemical monitoring might not have indicated a problem in Peak Creek watershed if performed during dry weather conditions. Biological analyses in this watershed were a cost-effective means to determine where ecological problems existed, the causes of those problems, and thereby, the necessary information with which to make informed management choices regarding remediation.

Maryland Biological Stream Survey: Developing Estimates of Watershed Condition

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The Maryland Department of Natural Resources (DNR) is charged with managing the natural resources of the state. Although site-specific studies have revealed adverse effects on streams from acidic deposition, no statewide or watershed-level information is available on the condition of stream resources in Maryland. To address the lack of comprehensive information on the biological resources affected by acidic deposition and other stresses, DNR is implementing the Maryland Biological Stream Survey (MBSS). The MBSS will provide a comprehensive and technically defensible assessment of the extent to which acidic deposition may have affected or may be affecting critical biological resources in the state. The survey will help decision makers identify the geographic distribution of biological resources, establish priorities for environmental issues of concern in Maryland's streams and rivers, and identify regions that require protection or mitigation (Southerland and Weisberg, 1995).

Characterizing the condition of the ecological resources in a watershed is critical to its effective management. Unfortunately, many watershed projects do not have reliable estimates of condition, because data are collected in an ad hoc fashion. Even relatively extensive monitoring data may fail to adequately characterize watershed condition if results cannot be extrapolated beyond individual sampling sites. The MBSS has been explicitly designed to provide area-wide estimates of biological condition. This includes a probability-based sampling design in which sites are selected from a comprehensive list of stream reaches in Maryland such that all sampling sites have a known, non-zero probability of being sampled. This sampling design will enable investigators to use data from the MBSS to estimate the condition of streams and rivers on watershed and statewide scales.

Random Sampling

MBSS Field sampling

Planning and execution of a sample survey involves three primary steps: (1) creating a list of all units in the target population (the sampling frame) from which to select a sample, (2) selecting a random sample of units from this list, and (3) collecting data from the selected units. The probabilistic sampling design has substantial advantages over nonrandom surveys because it enables investigators to estimate the condition of streams and rivers for any geographic region, ranging from small watershed to statewide scales. The design supports statistically valid population estimates of variables such as densities of particular species of fish or the number of miles of stream with degraded habitat. The MBSS sampling design also permits rigorous characterization of the sources of variability in the data.

The MBSS field studies involve collecting biological, physical, and water quality data during the spring and summer. Benthic macroinvertebrates and water quality paramenters are sampled during the spring; during the summer, fish and herpetofauna are sampled, and the physical habitat is evaluated. Biological variables are used to evaluate the ecological condition of streams within a region or watershed. Habitat indicators are used to evaluate the condition of the physical environment and determine how habitat condition contributes to ecological condition. Information about water quality and anthropogenic stressors are used to describe and identify potential causes of degraded ecological conditions.

The MBSS design incorporates a hierarchical arrangement of sampling units (Figure 1). First, the MBSS stratifies the nontidal streams of Maryland into 18 river basins (watersheds). Lattice sampling is used to schedule sampling of basins over the three-year study. Lattice sampling, or multistratification, is a cost-effective means of allocating effort across time in a large geographic area (see Cochran, 1977; Jessen, 1978). The MBSS study area was divided into three geographic regions with five to seven basins each: (1) western, (2) central, and (3) eastern. Each basin will be sampled at least once during the three-year study. The sampling frame for the MBSS was constructed by overlaying basin boundaries on a map of all blue-line stream reaches in the study area as digitized on a U.S. Geological Survey 1:250,000-scale map. A stream reach is defined as the section between two adjacent confluences, or between the head of the stream and the first downstream confluence. The stream reaches are further divided into nonoverlapping, 75-m segments; these segments are the elementary sampling units for which biological, water chemistry, and physical habitat data are collected. Random sampling of segments within each basin and stream order allows the estimation of unbiased summary statistics (e.g., means and proportions, and their respective variances) for the entire basin, or for subpopulations of special interest.

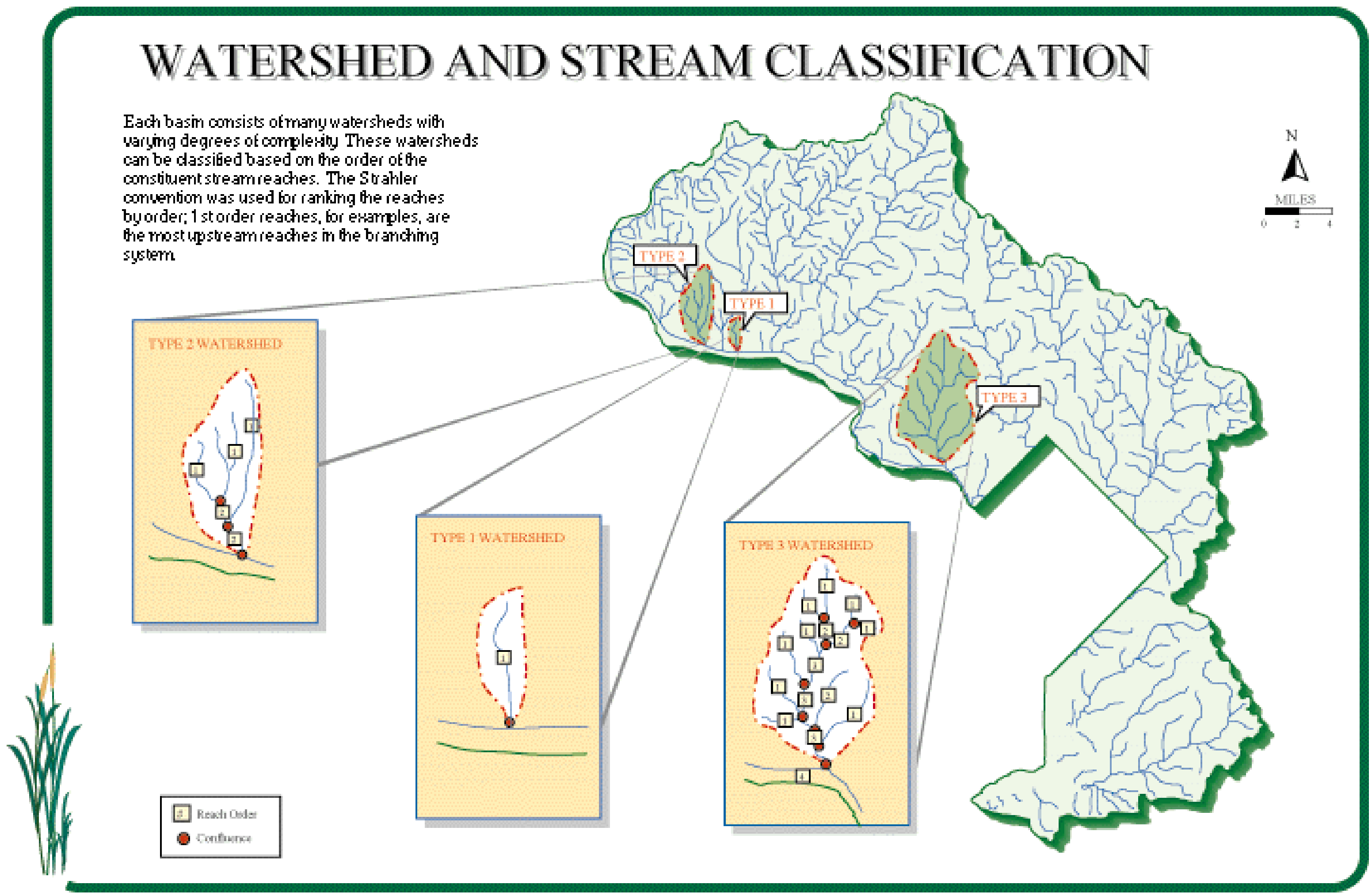

Figure 1.

The approach for sampling the streams of Maryland is basically the same as for an opinion poll. Instead of collecting the opinions of a sample of people, the MBSS collects data about stream chemistry, physical habitat, and biological assemblages from a representative sample of stream segments in a watershed to characterize its condition. For a basin and stream order, for example, the proportion of stream segments in the sample with ANC less than a critical value (e.g., 200) provide an estimate of the proportion of stream miles that has ANC below this value. MBSS's objective is to characterize the entire network of stream in the study area; therefore all stream segments in the area must be eligible for inclusion in the sample. We clearly would not get a good estimate of the percentage of stream miles with ANC < 200 in the entire state if measurements were taken only from acid sensitive streams. For estimating proportions, a great advantage of random sampling is the fact that the number of samples needed to achieve a satisfactory level of precision can be approximately determined in the planning phase.

Sampling Design

The specifics of a probability-based sampling design vary with the goals of the assessment and the funding available. The precision of estimates of condition is limited by the heterogeneity of the watershed and the number of samples taken. Given limited funds, designs for estimating watershed condition need to optimize apportionment of sampling effort based on the heterogeneity of watersheds. The MBSS is an example of an ambitious program with the goals of assessing the status of stream resources on both the statewide scale and finer scales. In the MBSS design, the ecological resources of interest (the target population) was restricted to nontidal, third-order and smaller stream reaches, excluding unwadable impoundments and impoundments that substantially alter the riverine nature of the reach. The target population was then subdivided into streams of different size according to the Strahler convention (i.e., first-order reaches are the most upstream reaches in a branching stream system). Different refinements (e.g., subdivision into subwatersheds) are possible, but the MBSS decided that reliable estimates of stream condition in all three orders were most critical to assessing the fishability and biological integrity of stream resources in Maryland (Figure 2). To obtain these estimates, approximately equal numbers of stream segments are sampled from each stream order across the state. For each stream order, the number of samples is approximately proportional to the number of stream miles in a basin. Stratifying by stream order ensures that enough samples are obtained to develop precise population estimates for various parameters in second-order and third-order streams. Although most stream miles are in first-order streams, higher-order streams contain relatively higher abundances and diversity of fish species.

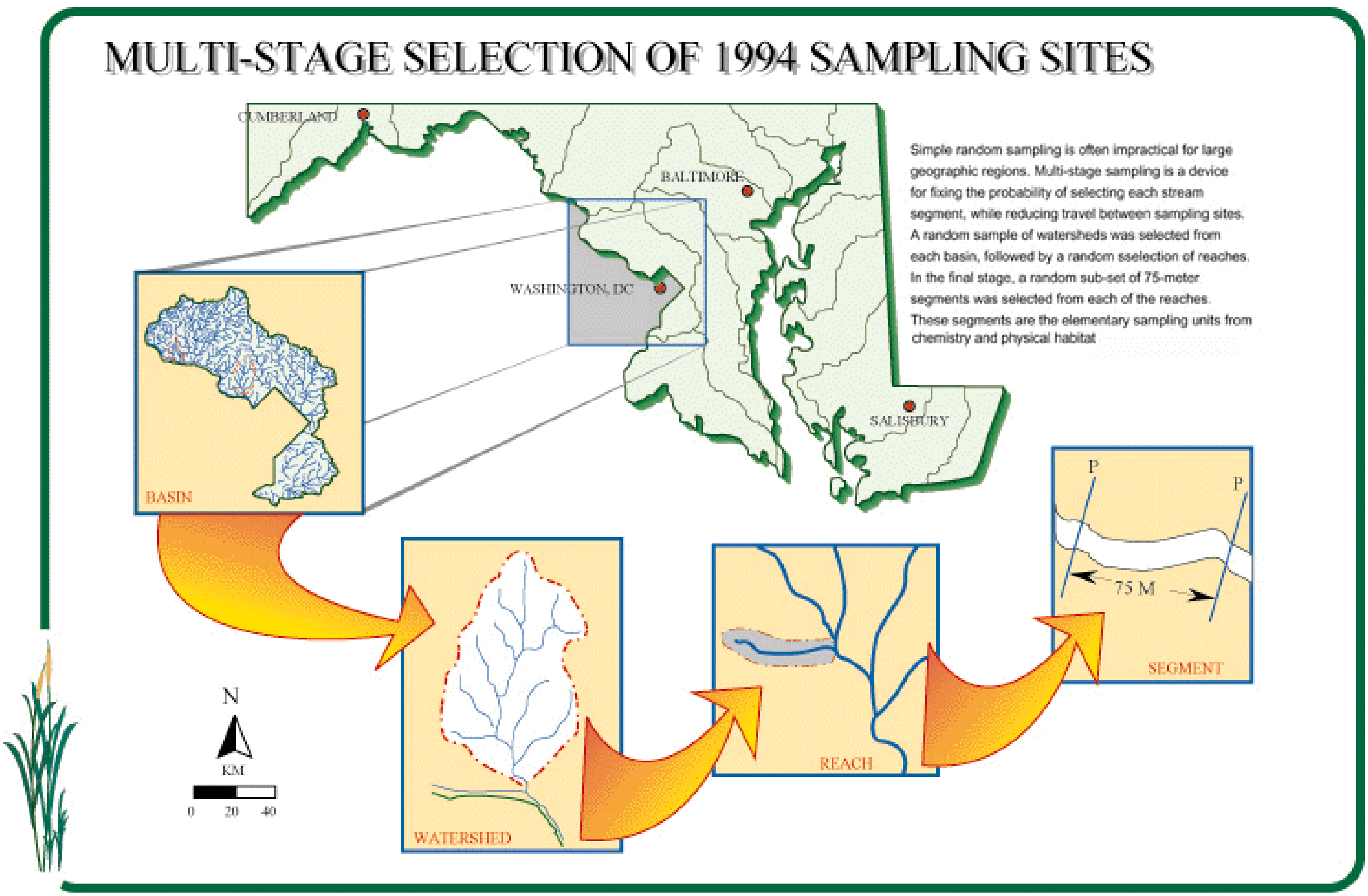

Figure 2.

Developing area-wide estimates of ecological resources also provides the opportunity to determine trends in watershed condition. Although the possibility of extending the MBSS has not yet been planned, such an extension would be required to effectively evaluate trends in biological resources and identify the consequences of the changes in atmospheric deposition expected to result from full implementation of the Clean Air Act Amendments of 1990. Several design options could be used if the MBSS is repeated; one efficient design for assessing status and trend in a resource is to sample with partial replacement (Cochran, 1977). In a future MBSS study, 75% of the sites could be selected randomly following the standard MBSS design; 25% of the sites could be at fixed at locations randomly selected as a subset of sites from the previous MBSS. This would provide watershed managers with reliable information on changes in the entire watershed rather than changes at individual sites.

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The Gulf of Maine Land-Based Pollution Sources Inventory: Lessons Learned in Building and Using a Tool for Regional Watershed Management

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Introduction

The Gulf of Maine watershed is extensive, covering 64,000 square miles in three states and three Canadian provinces. It includes 25 major watersheds and 11 minor coastal drainage areas (Figure 1), and stretches from the north shore of Cape Cod, Massachusetts, to Cape Sable, Nova Scotia in Canada. The waters of the Gulf of Maine include the rich fishing grounds of the Georges and Browns banks. Recent history has seen a decline in the quality of the Gulf's ecosystem as evidenced by shellfish bed closures and the depletion of the region's groundfishery, while the competition for the remaining resources has grown more intense. The Gulf of Maine Council on the Marine Environment, an alliance between the states and provinces, was established in November 1989 by the governors and premiers of the Gulf of

Maine, and has recognized the problem of increasing pressure on the ecosystem's health. One of the Council's major goals has been the development of a land-based pollution sources inventory. This inventory can be used to analyze and better understand the stresses on the ecosystem and to enable managers and policy makers to accurately assess environmental problems and set remedial or regulatory priorities (Maine Coastal Program, 1995). This comprehensive inventory will be the first ever developed for the Gulf of Maine region and it is a critical step toward interjurisdictional management.

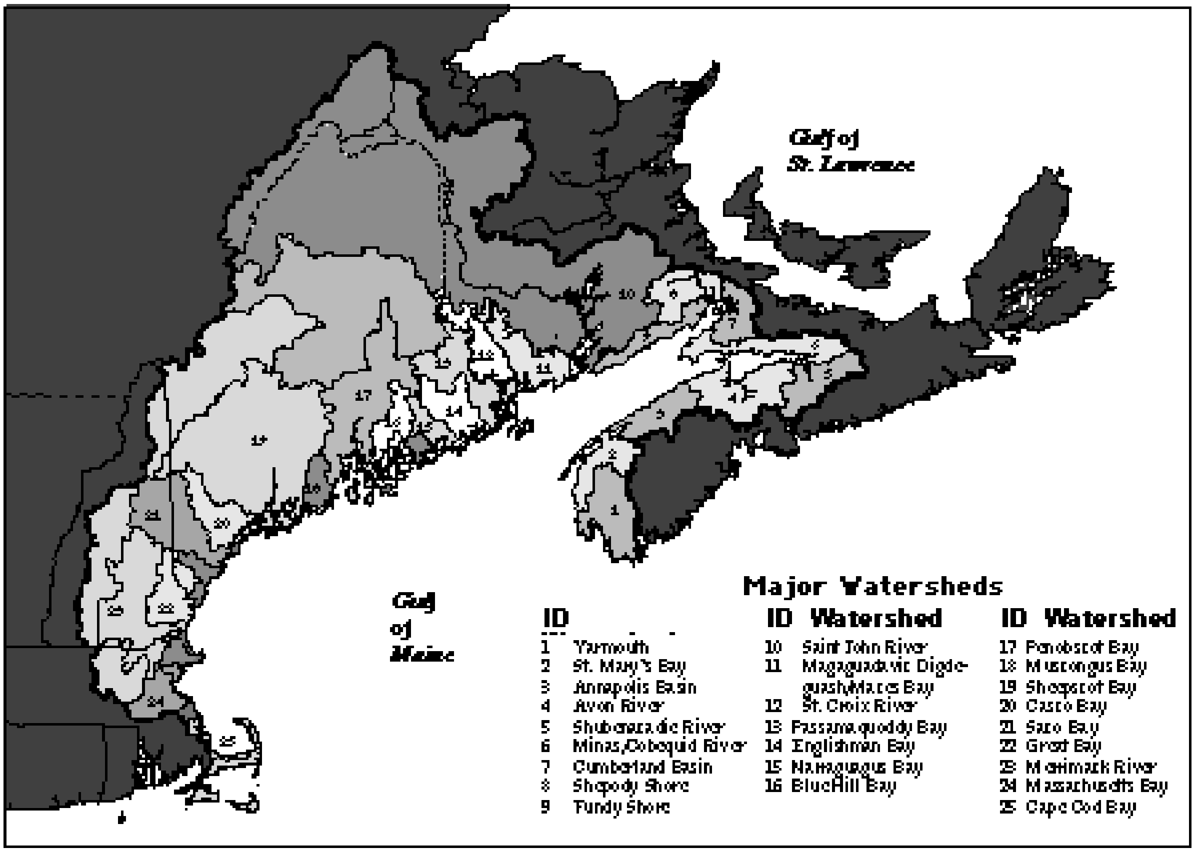

Figure 1. Major watersheds in the Gulf of Maine Region.

When completed in 1996, the inventory will give resource managers throughout the Gulf an overall picture of pollution sources in the region, allowing them to develop appropriate control strategies and monitoring programs. It will also provide information on the location, timing, and magnitude of point and nonpoint sources discharging to the rivers, streams, lakes, and estuarine and coastal waters of the Gulf of Maine drainage area, as well as on the existing and future relative contributions of point and nonpoint pollutant discharges within and among watersheds. With this information, managers will be able to target financial and human resources to the programs that will have the greatest impact on pollution problems and that will benefit those who depend on the Gulf's resources. The inventory can also be used to support the design of joint marine monitoring efforts and aid in implementation of management programs such as the Coastal Nonpoint Pollution Control Programs required by Section 6217 of the U.S. Coastal Zone Management Act Reauthorization Amendments of 1990. In the future, the inventory could be linked to a habitat suitability model to evaluate the impact of changes in pollutant loadings on estuarine ecosystems. This paper will discuss the efforts to develop the land-based pollution sources inventory and the lessons learned in the process of its development.

The Gulf of Maine Pollution Sources Inventory

Phase I-Point Source Inventory

The development of a point source inventory, the first objective given immediate priority by the Gulf of Maine Council in 1991, was completed in 1994 (NOAA, 1994). The inventory includes background data and pollutant discharge estimates for 273 major and 1,751 minor direct point sources discharging in the watersheds and coastal drainage areas of the Gulf of Maine. Annual and seasonal discharge estimates for a base year of 1991 are made for 15 parameters of concern based on their effect on water quality and on human health. These parameters are: flow, biochemical oxygen demand, total suspended solids, nutrients (nitrogen, phosphorus), heavy metals (arsenic, cadmium, chromium, copper, iron, lead, mercury, and zinc), oil and grease, and fecal coliform bacteria.

Pollutant loading estimates for U.S. facilities were based on data from self-monitoring reports required by each facility's National Pollutant Discharge Elimination System (NPDES) permit. When this information was not available, staff used the facility's permit discharge limits. If monitoring or permit pollutant data were both unavailable, typical pollutant concentration values associated with the facility's industrial activity or level of wastewater treatment were used to make the estimate (NOAA, 1993). Information in the inventory can be aggregated by watershed, eight-digit U.S.G.S. hydrologic cataloging unit, the 11-digit subbasins that make up watersheds, or by county or province. For Canadian facilities, monitoring information and facility design flows were used when provided by Canadian government officials, and typical concentration values were used if this information was not available.

Phase II-Nonpoint Source Inventory

The development of a nonpoint source inventory, the Council's second objective, is not yet complete. An attempt is being made to model the runoff and sediment yield of the U.S. portion of the Gulf of Maine region using an integrated approach which includes: 1) a hydrological model to predict the surface and sub-surface water quantity; 2) a geographic information system (GIS) to collect, manage, analyze, and display the spatial and temporal inputs and outputs; and 3) a relational databases to manage the nonspatial data and drive the model. The system divides the Gulf of Maine (U.S. portion) into 422 subbasins (polygons), and the model inputs were derived for each polygon. The simulation is for a five-year period (1989-1994). For all the subbasin areas, information is needed to characterize land use, climate, soil properties, and topography. The spatial databases were assembled at both 1:24,000 and 1:250,000 scales using the Geographical Resources Analysis Support System (GRASS).

One of the innovative aspects of the project is the use of a watershed-scale modeling capability called the Soil and Water Assessment Tool (SWAT) to estimate nonpoint source discharges and route the loadings through each watershed to the estuary (Arnold et. al, 1993). The SWAT model, which is being developed jointly by the United States Department of Agriculture (USDA)'s Agricultural Research Service and Texas A & M's Agricultural Experiment Station in Temple, Texas, in close cooperation with the project team, combines a watershed model known as "Simulator for Water Resources and Rural Basins (SWRRB)" and a river routing model called "Routing Outputs to Outlets (ROTO)" within the GRASS environment. The subbasin components of SWAT can be placed into eight major divisions: hydrology, weather, sedimentation, soil temperature, crop growth, nutrients, pesticides, and agricultural management. The input interface programs and other tools are written in the compiled language C, and are integrated with the GRASS libraries (Srinivasan and Arnold, 1994). The model itself is written in FORTRAN 77, and both the interface and model run within the UNIX environment. The SWAT model is undergoing a continuous refinement and adaptation to a wider range of hydrologic and environmental problem solving abilities. For the Gulf of Maine project, it has been updated to include improvements for urban runoff, snow melt and instream water quality.

A Unique Partnership

What makes this inventory unique is its spatial scale and the fact that it brought Federal, State, and provincial partners working in the Gulf of Maine together with the common goal of developing a practical management tool. The partners include two groups within the National Oceanic and Atmospheric Administration (NOAA): the Pollution Sources Characterization Branch (PSCB) of the Strategic Environmental Assessments (SEA) Division, and the Office of Ocean and Coastal Resource Management (OCRM)'s Coastal Programs Division (CPD). Other partners include The Gulf of Maine Council on the Marine Environment (including the coastal programs of Maine, New Hampshire, and Massachusetts) and several offices within the provincial governments of New Brunswick and Nova Scotia. Input from all these organizations has ensured the development of a truly regional inventory. Among the partners, PSCB is responsible for building and refining the land-based pollution sources inventory. The CPD is providing guidance and insight on policy issues and is helping to coordinate partners. The State coastal programs are playing a major role in coordinating the review of the inventory and exploring the potential use of the information to support State program needs.

Results of the 1991 Inventory

The major results drawn from the analysis of the point source component of the inventory include:

- There are 273 major and 1,751 minor facilities in the study area. Sixty-nine percent of these facilities (1,406) are in the Unites States.
- In the United States, there are 1,069 active industrial facilities, 252 wastewater treatment plants, and 85 power plants; in Canada, there are 492 industrial facilities, 126 wastewater treatment plants, and 8 power plants.
- In the United States, wastewater treatment plants produce over half of the total load discharged for all 15 pollutants, although industrial facilities alone are responsible for approximately 38 percent of the chromium discharges in the study area. In Canada, wastewater treatment plants are responsible for the greatest portion of the total pollutant loads for total nitrogen, total phosphorus, arsenic, cadmium, chromium, copper, iron, lead, mercury, oil and grease, and fecal coliform bacteria, while industries have higher discharges of process flow, biological oxygen demand, total

suspended solids and zinc.

- U.S. facilities account for approximately 84 percent of the process flow discharged into the Gulf of Maine. The Massachusetts Bay watershed alone accounts for over 36 percent of this flow in the study area. Three other watersheds account for and additional 38 percent of the total process flow in the study area. These are Sheepscot Bay watershed (76 billion gallons), Merrimack River watershed (66 billion gallons), and the Saint John River watershed (56 billion gallons). Wastewater treatment plants are the primary source of process flow for both the Massachusetts Bay and Merrimack River watersheds, while industry is the major source for the watersheds of Sheepscot Bay and Saint John River.
- The (MWRA) Deer Island and Nut Island treatment complex in Boston is the largest overall discharger with a combined flow of 139 billion gallons per year. It is responsible for more than half of the region's point source discharge of biochemical oxygen demand, total suspended solids, and iron. It also has the highest discharges for 12 of the 15 pollutants in the inventory.
- The International Paper Company facility in Jay, Maine (Sheepscot Bay watershed) accounts for the largest industrial discharges of process wastewater, biochemical oxygen demand, total suspended solids, chromium, and zinc in the region.

Results from the nonpoint pollutant source inventory were not available at the time this paper was written, but will be presented at the Watershed '96 Conference.

Lessons Learned in Developing the Inventory

The Inventory project is an ambitious effort to develop an inter-jurisdictional management tool for regional and state/province level analysis. Some of the most important lessons learned by the team that may of value to others engaged in developing large scale source inventories include:

- Monitored Data are Scarce. Although a significant effort was made to collect and use monitoring data, the pollutant discharge estimates still rely heavily on typical pollutant concentration approach, particularly for minor facilities in both countries. However, since the inventory has a built-in audit trail, the typical estimates can be screened out if the user only wants to evaluate values based on monitoring data. The fact that the vast majority of permits for point source facilities in the study only require monitoring for a limited number of pollutants raises the question of whether monitoring for additional pollutants should be required, at least for the major facilities that contribute the bulk of the pollutant loadings. The inventory can be used to identify those major facilities for which additional permit requirements should be considered.
- The Accuracy of Estimates Varies. As discussed above, the capability to generate accurate discharge estimates is limited by the scarcity of monitored pollutant data. For many pollutants, loads were based on assumptions about typical pollutant concentrations in the waste stream, volume of flow in the pipe, and the type of wastewater (e.g., process, cooling, a combination of both, or domestic sewage effluent) discharged. In general, estimates for wastewater treatment plants are better than for complex industrial facilities because treatment processes are less variable for the treatment plant. It was not possible to quantify the error by assigning numerical confidence

limits to the estimates. However, by tagging each estimate with a data source and computational basis code, an effort was made to provide a means of evaluating the relative confidence that can be placed in the estimate.

- Latitude/Longitude Data are Incomplete. The assignment of all facilities to watersheds (e.g., eight-digit hydrologic cataloging units) proved to be a difficult task because of incomplete and inaccurate latitude/longitude information. If a river reach number for U.S. facilities or the Canadian equivalent was available it would greatly improve the accurate aggregation of facilities in small watershed units.
- Timeliness is Important. The inventory is a snapshot in time-a picture of pollution discharges in 1991. For screening-level assessments, loading estimates can be considered reasonably representative of discharges from 1992 to 1995. In general, this assumption is better for discharges from wastewater treatment plants, which vary less over time, than from industrial activities, which are more sensitive to changes in production levels tied to economic conditions.
- Reconciling Differences in Data Variables is Time-Consuming. To achieve consistency in the Gulf of Maine database, a considerable amount of time and effort was needed to understand the meaning and account for differences between several U.S. and Canadian data variables (e.g., the Standard Industrial Classification system).
- Building a Complete Inventory is Difficult. Compiling a comprehensive and current inventory of facilities in a large area is a difficult task. In any given time period, some facilities begin or change operations, others cease operating permanently, and some change ownership and name. Resolving discrepancies in the exact number, type, and discharge characteristics of facilities in an area is time- consuming and often unsuccessful. Nevertheless, the project team believes the inventory contains a reasonably complete listing of the dischargers in the study area.
- Data Collection and Processing are Always Underestimated. The time frame to collect and process data and improve computer model algorithms always takes longer than originally anticipated. This is a factor to be planned very carefully. The Project Team faced problems associated with data release agreements, compatible data media and data format issues, and resolving differences in input data sets, which caused the completion of the project to be delayed. One particular example was the processing of 8,500 subbasins in Maine to aggregate them to a subbasin size compatible to those in Massachusetts and New Hampshire. A computer algorithm had to be written that used digital elevation information to accomplish this grouping. While the delay was unfortunate, the improvements to the model and the resolution of the input data sets will result in better estimates and model results for State partners because they will match the spatial framework used by each state in its water quality management efforts.
- Outreach is Important. This project built good working relationships between the partners, and the inventory has been perceived as a very useful tool to augment the work of scientists and managers in the region (Moore and Truesdale, 1995). However, many potential users are still unaware of the preliminary results and capabilities. A well-designed communication plan detailing how to access and use the inventory would address this problem.

Next Steps

The complete inventory and a summary report presenting the results will be available in the summer of

1996. The digital contents of the point source inventory are currently available in ASCII format on NOAA's Internet server (the Internet FTP address is: "seaserver.nos.noaa.gov" and the files are in the directory "/public/percy/gomaine"). The Gulf of Maine Program, in cooperation with the project team, is evaluating possible improvements to the inventory, including:

- Incorporating additional data to update estimates for point and nonpoint source pollutant loads;
- Refining information for minor point source facilities;
- Improving spatial resolution (e.g., modeling at the 14-digit subbasin level);
- Completing the Canadian portion of the nonpoint source inventory;
- Overlaying other data to improve the utility of the Gulf of Maine Project (e.g., shellfish closures information to be correlated with pollutant discharges);
- Providing the inventory in several GIS formats; and
- Increasing awareness and access to the inventory (e.g., putting all or a portion of the inventory into a desktop information system to make the data more accessible to a broader group of users).

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Modeling Nitrogen Cycling and Export in Forested Systems at the Watershed Scale

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Web Note: *Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

The Chesapeake Bay Watershed Model (Linker et al. 1993) provides nutrient loadings to the Chesapeake Bay Water Quality Model for use in estimating the impacts of land use and other management scenarios on water quality in the Bay. The nonpoint loadings are defined by the various land use categories in the Watershed Model, which include forests, cropland, pasture, haylands, urban, and animal waste areas. The U.S. EPA Hydrologic Smulation Program-FORTRAN (HSPF) (Bicknell et al. 1992) provides the framework for the Watershed Model, and the AGCHEM module within HSPF is used to model nutrient cycling and export for the croplands and haylands.

A recent review of the nitrogen loadings calculated by the Watershed Model indicates an over-prediction of nitrogen loadings from forested segments of the model. Under a joint USGS/EPA effort to improve AGCHEM for representing nitrogen mass-balance modeling for forest areas at the watershed scale, a number of refinements have been implemented and are being tested based on recommendations by Oak Ridge National Laboratory (Hunsaker et al. 1994).

The primary inputs to forests are atmospheric deposition and nitrogen fixation, and the primary losses are leaching and denitrification. Important processes are retention of ammonium by the soil, mineralization of organic N, and uptake of available nitrogen by plants. Typically, forests are deficient in nitrogen, and consequently, they tend to retain input nitrogen. However, after long term nitrogen inputs, forests can eventually become saturated, at which point the combined effective inputs of mineralization and atmospheric deposition may exceed the capacity of the plants to take up the available nitrogen. At this point, nitrogen exports, particularly nitrate, begin to increase. The needs of the forest nitrogen model for the Chesapeake Bay are representation of the principal state variables already considered in the Watershed Model, representation of the important variables and processes in forests, responsiveness to atmospheric deposition, and ability to generate the expected magnitude and timing of nitrogen exports.

The nitrogen transformations, nutrient storages, and reaction rates considered by HSPF, as modified in this effort, are shown in Figure 1. Each of the subsurface processes and compartments (i.e., not aboveground plant N, litter N, or related processes) occur in each of the four soil layers modeled in the AGCHEM module. The forest-related modifications include the following:

- The particulate organic nitrogen state variable was subdivided into four soil organic nitrogen state variables: labile particulate, labile solution, refractory particulate, and refractory solution. The particulate labile fraction is assumed to convert to the refractory form using first-order kinetics, and both particulate species are assumed to leach to the solution forms using a simple partitioning function.

- Because uptake of inorganic nitrogen from forest soil can be saturated at high nitrogen concentrations, an optional method was added for modeling nitrogen uptake and immobilization, using saturation kinetics instead of first-order kinetics.

- The plant nitrogen state variable was subdivided into aboveground and belowground compartments.

- A litter nitrogen compartment was added to provide an intermediate compartment between the aboveground plant nitrogen and the surface and upper layer organic nitrogen.

- New pathways were added to allow plant nitrogen in the aboveground and belowground compartments to return to the litter and organic nitrogen in the soil using first-order kinetics.

Additional modifications were made to the AGCHEM module to improve nitrogen modeling in agricultural areas. Ammonia volatilization was added for conditions where animal waste or fertilizer applications warrant this mechanism; soil fixation by leguminous plants was added; and a yield-based plant uptake option was included to make the model more sensitive to nutrient applications.

Model application and calibration requires estimation of the expected soil nitrogen storages and fluxes, as well as parameterization of the model. In the absence of comprehensive site-specific data on the nitrogen mass balance in forested watersheds, we have developed an expected mass balance (Table 1) based largely on literature values compiled from the review by Oak Ridge. These estimates are being used to test the new system on forested, small research watersheds in Pennsylvania and Maryland using nitrogen loss data collected by the USGS. As is suggested by the information in Table 1, the primary difficulty in calibrating the model is related to balancing the large storages of plant and organic nitrogen over long periods with small inorganic storages, relatively small process fluxes, and attaining the observed seasonal variation in nutrient concentrations and loadings in discharge from the watershed. In particular the seasonal timing of mineralization, plant return, and uptake fluxes are critical to the plant nitrogen storage and accurate estimation of loadings.

Table 1. Expected Nitrogen Balance for Forest Soils.

a. Storages (kg/ha)	**Mean or Range**	**St.Dev.**
Aboveground plant N	**456**	**199**
Belowground plant N	**106**	**96**
Litter N	**20-30**	**-**
Surface soil N	**735**	**643**
Mineral soil N	**5749**	**2513**
b. Fluxes (kg/ha/yr)	**Mean or Range**	**St.Dev.**
Plant uptake	**116**	**58**

Aboveground plant return to litter	**35**	**18**
Belowground plant return to soil	**50**	**19**
Denitrification	**0.2-2**	**-**
Mineralization in forest floor	**13**	**20**
Mineralization in mineral soil	**42**	**40**
Input (atmospheric deposition)	**6-13**	**-**
Output (erosion and discharge)		
Nitrate **Ammonium** **Organic N**	**0.04-2.4** **0.07-0.18** **0.2-1.7**	**-** **-** **-**

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GIS Watershed Assessment Model for Suwannee River Basin

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Introduction

On March 22, 1995 the Suwannee River Water Management District (District) authorized Soil and Water Engineering Technologies, Inc. to perform environmental related assessments of their entire District through the development of a watershed Geographic Information System (GIS) assessment model. The study area includes the Suwannee River drainage basin (19,400 km2) within the State of Florida.

The overall objective of the GIS watershed assessment project is to identify and develop specific criteria and assessment algorithms that reflect the relative impacts of land use, soils, hydrography, and wetlands on the discharge water quality, wetlands value, and flooding impacts. Two methods or sets of watershed assessment algorithms were developed as part of this project. The first method provides spatial assessment using impact indices, and the second method utilizes hydrologic and contaminant transport modeling. The method used depends on the watershed assessment parameter of interest. The indexing approach is used for assessment parameters (BOD, coliform bacteria, and toxins) that are hard to quantify or are not directly associated with pollutant transport, while the modeling approach addresses the major pollutants of sediment and nutrients. Both approaches provide outputs at both the source cell and sub-basin outlet level.

Model development and testing is nearly complete for a pilot area (North New River, approximately

80,000 hectare). A brief discussion of the assessment procedures, data sources, and operational techniques for the GIS watershed assessment model developed thus far are summarized in this paper. The model will be extended to the entire District during 1996.

Watershed Assessment Approach

The general approach to perform the watershed assessment is to use the District's comprehensive GIS databases (land use, soils, hydrography, topography, and basin delineation) and known pollutant transport processes to locate the areas within the District that have the greatest potential for adverse impacts on the environment. The goals are to locate the problem areas and to quantify the relative impact on a watershed-by-watershed basis across the entire District. The assessment impact parameters evaluated are: water quantity, nitrogen, phosphorus, sediment, biological oxygen demand (BOD), coliform bacteria, toxic/hazardous materials, wetland habitat value, wetland value for water quality treatment, and potential flood proneness. For each of the above parameters, the products of the assessment program are maps of the relative ranking/index for each impact parameter across the pilot area (eventually across the entire District) and the cumulative ranking/index by watershed/subbasin.

The actual ranking or indexing of the various assessment impact parameters is accomplished by using two assessment approaches depending on the impact parameter being evaluated. An indexing approach is used for the following assessment impact parameters: BOD, coliform bacteria, toxic/hazardous materials, wetland habitat value, and wetland value for water quality treatment. A modeling approach is used for water discharge, flood proneness, and loads of nitrogen, phosphorus, and sediment. Two approaches are used to reflect the relative importance of the various impact parameters and their ability to be modeled using available data. Based on current and anticipated future land uses, it is felt that nutrients (nitrogen and phosphorus) and sediment have the greatest potential for causing adverse impacts in the streams, wetlands, rivers, and estuaries within the District. This decision, combined with the fact that only hydrologic/nutrient transport models have been effectively tested for use in watershed assessments, justified the decision that only the water, nitrogen, phosphorus, and sediment loads should be simulated dynamically.

The indexing and modeling approaches are similar because both use the watershed characteristic data from the District's GIS coverages to select the appropriate input data (indices for index approach and model parameter sets for modeling approach) used to calculate the combined impact of all the watershed characteristics for a given grid cell/polygon. Once the combined impact for each unique cell/polygon within a watershed is determined, the cumulative impact for the entire watershed is determined by first attenuating the constituent to the sub-basin outlets and then calculating an area-weighted ranking/index for the attenuated load generated at each cell. Constituents are attenuated based upon the flow distances (overland to nearest water body, through wetlands or depressions, and within streams to the sub-basin outlet), flow rates in each related flow path, and the type of wetland or depression encountered.

The resulting ranking/index provides a good comparative tool for assessing the spatial importance of the land use, soils, wetlands, depressions, and hydrography within a given watershed and across different watersheds. The simulated results are not intended to provided precise load estimates for the individual watershed impact parameters, but are intended to provide a relative index of the potential environmental impacts.

GIS Model Interface

The Suwannee River Watershed Assessment Model (SRWAM) is written for ARC/INFO 7.0. ARC/INFO is the widest used GIS software in Florida and is currently used by virtually all of the water management districts in the State including the Suwannee River Water Management District.

The programming language, ARC/INFO Macro Language (AML), was used to develop a customized menu interface specifically designed to allow the user to control the model environment. There are three menus and one display window opened simultaneously when the model is activated. A main menu is provided that includes eight primary selections: Project, Update, Spatial Extent, Display, Edit, Model, Output, and Help. A Tool menu provides various utilities for zooming, panning, querying, etc. coverages that are currently shown in the display window. The final menu consists of a dialog box located next to main menu options. This is simply an area where messages are conveyed to inform the user of the processes taking place and occasionally prompt the user for information. It is referred to as a menu in ARC/INFO.

All of the input and output information generated from a model session is stored in a workspace (or subdirectory). This workspace is referred to as a Project for data management purposes. The user is allowed to create a new Project, open a previous Project, save or rename a current Project and manage Projects. The Manager option provides a valuable means of tracking, describing, and removing Projects.

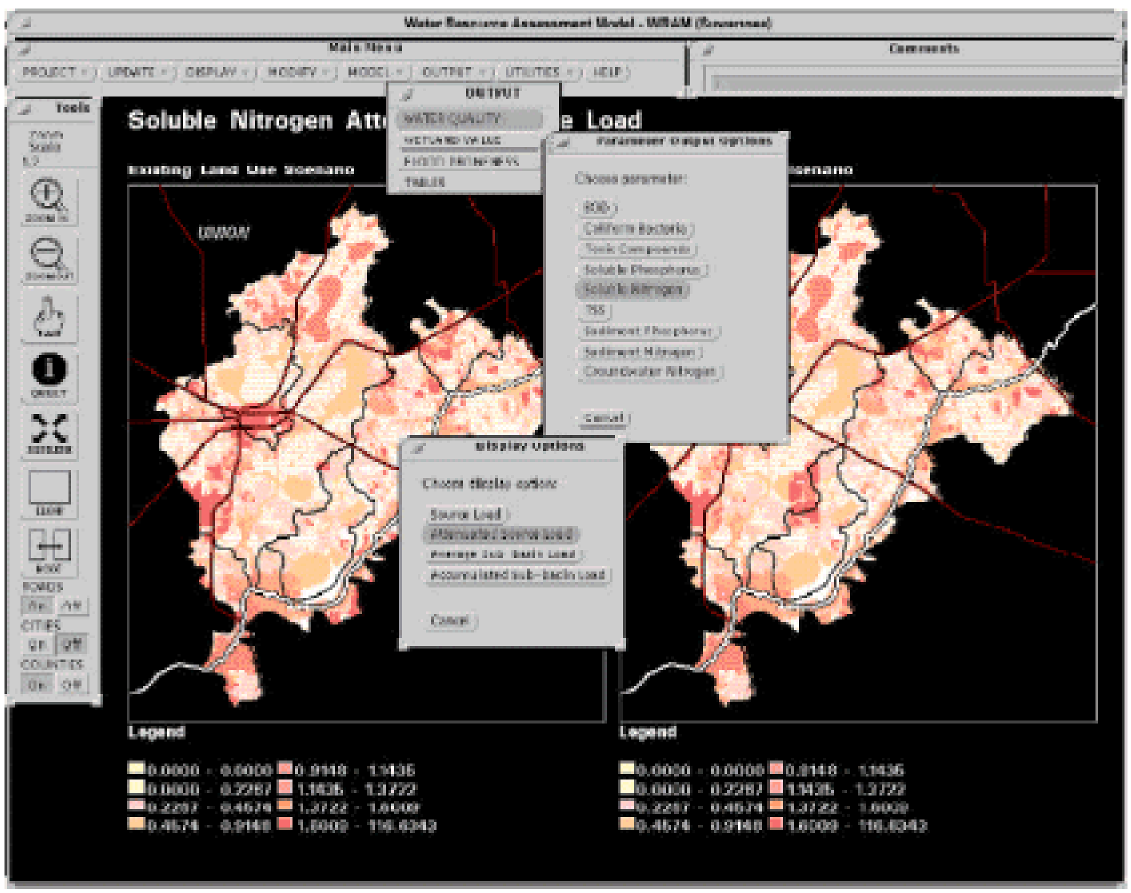

Figure 1: Example of Model Interface

Because of the time involved creating the coverages needed to run the model, many coverages are pre-processed. Occasionally, the existing vector coverages such as hydrography and land use might have to be replaced with newer versions. If so, the default model coverages will need to be pre-processed again. When the Update option from the main menu is selected, a new menu opens that prompts the user through this process and recommends (based on the changes that have occurred) which algorithms should be run. The other menu options are provided to select regions of interest, update coverages, run assessment models, customize outputs, and display maps.

GIS Modeling Techniques

There are several AML algorithms written for SRWAM that ultimately are used in three submodels: Water Quality, Wildlife Habitat and Flood Proneness. ARC/INFO GRID plays a major role in the algorithms because it is fast and powerful. A grid is simply a raster representation of a geographic coverage. The coverage becomes an image (or bitmap) that consists of several small square cells (0.21ha of data. The advantage of GRID as opposed to vector analyses (polygons) is that the time associated with re-assembling the topology (coordinate data) is not required. GRID also includes several analytical and relational functions that are fully exploited by SRWAM.

The Water Quality and Flood Proneness submodels both need depressional areas which are determined based on a combination of several coverages including hydrography (streams), wetlands, soils, and topography. Topographic depressions are determined by converting a vector coverage of USGS topographic contours into an grid and applying a GRID SINK function. Other potential depressions are determined through a geographic elimination process. Wetlands and certain soils that exhibit depressional characteristics are combined into one coverage and potential areas are reduced further based on land slope and proximity to streams.

The Water Quality submodel requires a series of attenuation runoff lengths. First, runoff lengths from each source cell to either wetlands, streams, or depressions are calculated. Depending on which one of these three features is found by the source cell first, additional attenuation lengths are found and returned to the source cell. For example, if a wetland is found, the source cell needs to know the distance from that point of contact on the wetland to the nearest stream. The source cell then also needs to know the distance from that point of contact on the stream to the sub-basin outfall. These distance calculations are accomplished with the GRID function, COSTDISTANCE, applied to the topography grid. This function returns the "least cost" path distance to cells of a specified grid based on values of another grid. By using the topography grid as the value grid, the path is determined based on the lowest elevations around the source cells.

Of course, the advantage of any GIS is the ability to overlay information and create new data sets. The Water Quality model requires such an overlay of land use and soils to determine the unique combinations that exist. These unique combinations are summarized and distributed to a FORTRAN program, BNZ (Cooper and Bottcher, 1993), which estimates loads for various parameters. The output from BNZ is then joined to the original land use/soils combination grid which, in turn, is combined with the attenuation distance grids. Another database containing attenuation coefficients is also joined to the coverage. The resulting coverage database includes all of the information necessary for the attenuation formula. Sample results for soluble P are shown in Figures 2 and 3, where light to dark shades indicates increased P load.

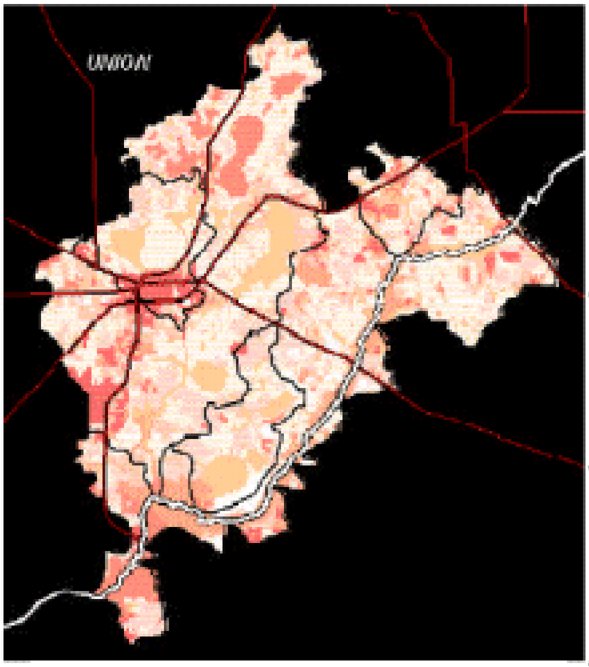

Figure 2: P Load per Source Cell

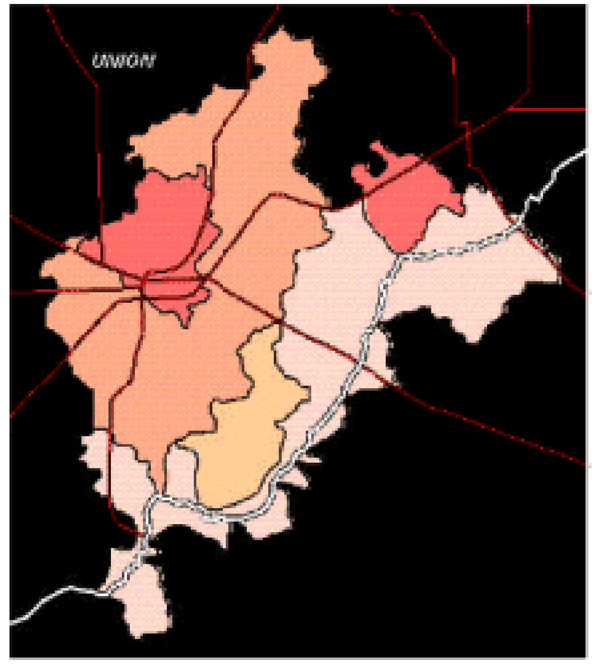

Figure 3: P Load per Sub-basin

The Wildlife Habitat submodel estimates the animal diversity index for each wetland cell. Wildlife Aerial Influence (WAI) indices, which represent the relative negative impact of neighboring land uses on wildlife within a wetland, are joined to the land use grid and wildlife diversity indices are joined to the wetland grid. The GRID function FOCALMEAN achieves a "moving window" effect by creating a new grid with values equal to the mean WAI of the cells in a specified neighborhood block (300m x 300m). This new value represents a factor (<1) to be applied to the wetland wildlife indices by multiplying the two grids together. The result is a wetland grid with values equal to an Adjusted Wildlife Index (AWI) that gives the relative animal diversity expected in a given wetland cell.

The Flood Proneness submodel utilizes the topographic depressional areas determined earlier and calculates the extent of flooding in these areas based on a given rainfall event. GRID hydrologic functions are available to determine the drainage area contributing to each depression. Modified land use/soils combination grid and topography grids are then created with extents equal to the depression contributing areas by using the GRID SELECTMASK function. A database containing CN numbers is then joined to the land use/soils combinations. The rainfall (user input) and the CN numbers are then used to calculate runoff volume per cell. The GRID ZONALSUM function is then used to determine the total volume of runoff that is generated for each depressional area. Available storage calculations are performed in a do-loop at one foot increments to determine the stage reached by the floodplain.

Summary and Conclusions

A GIS watershed model has been developed that performs the following assessments for a watershed:

- Maps of existing GIS coverages
- GRID (0.2 ha cells) load index maps for water quantity, nitrogen, phosphorus, sediment, BOD, coliform bacteria, and toxic/hazardous materials (see Figure 2)
- GRID (0.2 ha cells) index maps of wetland habitat value, wetland value for water quality treatment, and potential flood proneness
- Basin ranking coverages for each of the above assessment parameters (see Figure 3)
- Differential impacts of implemented management practices by GRID cell and basins

The model provides an excellent tool for regional planners to determine current areas under environmental stress and to estimate future impacts of land use management decisions.

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Geographic Information Systems for Water Quality: Examples from the Little Bear River and Otter Creek, UT

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Within the arid and semi-arid west, water quality often is considered the most critical resource management issue. Water quality problems typically arise through a variety of nonpoint source (NPS) pollution sources. Foremost among NPS problems is the origin and delivery of sediment to stream channels and waterways. Sediment enters stream channels through a variety of processes including streambank and hillslope erosion, runoff from agricultural surfaces or irrigation return flows, and mobilization of stream or floodplain deposits. This study describes attempts to identify potential sources of NPS pollution to two stream systems in Utah. The data are organized within a Geographic Information System (GIS) environment.

Study Watersheds

Analyses described here were conducted using data from two watersheds in the state of Utah. The first basin is the Little Bear River watershed located in Cache County, Utah. The basin is approximately 800 km2 in size and includes two reservoirs primarily used for irrigation water supply. The second watershed is the Otter Creek basin located in Sevier and Piute Counties, Utah. This basin is approximately 600 km2 in size and has one reservoir located in the upper portion of the basin. These two basins have been designated as Hydrologic Unit Areas (HUAs) for water quality improvement. Primary impacts to water quality include sediment loading from agriculture and accelerated stream bank erosion, nutrient loadings from livestock waste, and loss of stream and riparian habitat.

GIS Framework

GIS development was conducted using ESRI Arc Infoc and ERDAS Imaginec software. In general, image analysis was conducted using Imagine whereas topographic and hydrologic analyses were conducted using Arc Info. Within the study watersheds, data and analyses are organized at three spatial scales: the watershed, reach, and field (site) scale (after O'Neill et al., in review). These three spatial scales provide valuable resource information for water quality management decisions within the watersheds. We also consider temporal data in our analyses. Temporal data are incorporated through historic flow records, repeat field surveys, and historic aerial photographs. Table 1 identifies examples of data resources and analyses conducted at the three spatial scales.

Table 1. Examples of coverages and data analyses for designated spatial scales.

Spatial Scale	Data Resource	Analyses
Watershed	USGS Digital Elevation Models, Landsat TM imagery, Utah GAP Analysis Data	Slope, Aspect, Flow Accumulation, Land Cover Types, Land Ownership
Reach	Historic Aerial Photographs, Multispectral Videography	Channel and Riparian Change Maps, Extent and Condition of Riparian Vegetation, Reach Classification
Field (site)	Topographic and Vegetative Field Surveys, USGS Gaging Station Records, Water Quality Monitoring Data	Site Evaluation, Flood Frequency Analyses, Repeat Photo Points

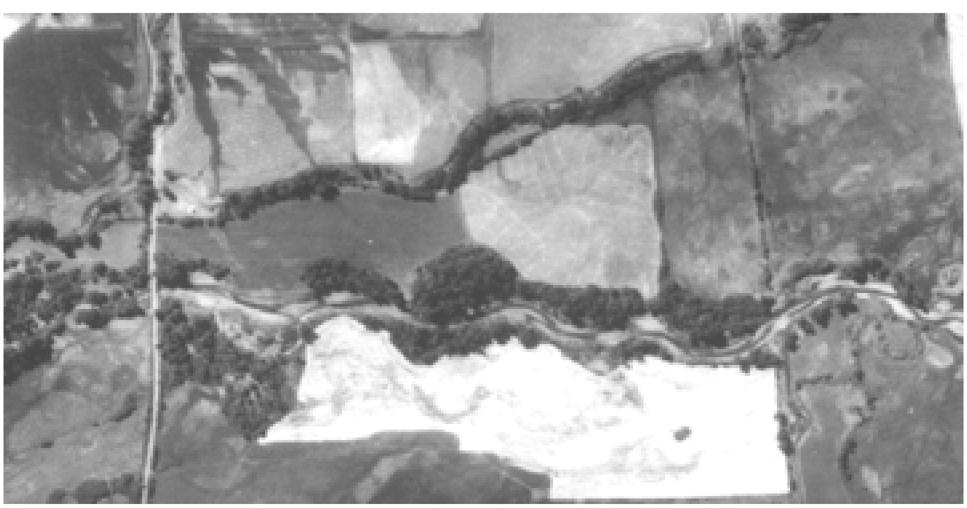
Watershed Scale

At the watershed scale, our efforts focus on watershed characterization and resource or land cover inventory. Topographic characterization of the basins include slope frequency distributions and hypsometric curves. These data provide us with a generalized comparison of physiographic basin conditions. We use hydrologic tools in Arc-Info (ESRI, 1995) to construct coverages that provide us with an estimate of the proportion of upstream basin area that consists of different physiographic or land cover conditions. For example, we can determine the proportions of pinyon-juniper forest, sagebrush, and agricultural areas upstream from any point on the stream network. These estimates of basin cover can then be related to point measurements of water quality or stream condition (described below). Alternatively, we can estimate the proportion of upstream area (by cover type) where slopes exceed a specified threshold. Combinations of slope and cover type then can be used to provide relative estimates of sediment production from hillslope surfaces. We also use models of relative wetness (see Phillips, 1990; Russell, 1994; O'Neill, in press) to describe watershed conditions for potential wetland or riparian restoration sites at the watershed scale. These wetness models are based on contributing area, local slope, and relative estimates of solar insolation.

Reach Scale

At the reach scale, we focus our efforts on segments of the main valley and relatively large tributaries. Data collected at this scale include longitudinal profiles (from USGS topographic maps), historic aerial photographs, and multispectral videographic imagery. We derive unit flows (Q/A) from hydrologic data (see below) and then construct spatially distributed values of discharge using drainage area calculations derived from watershed hydrologic tools (ESRI, 1995). Discharge estimates then are combined with slope data from longitudinal profiles and measures of valley width to generate total stream power (W = gQ10Sv) or specific stream power (w = gQ10Sv/Wv) at the reach scale, where g is specific weight of the fluid, Q10 is the estimated ten year flood, Sv is valley gradient and Wv is valley width. These reach based estimates of stream power can then be used to guide management decisions regarding restoration and resource management (see below).

Historic aerial photographs and multispectral videography provide detailed data regarding stream and riparian condition at the reach scale. Figure 1 presents an example of these data. At present, we are using historic aerial photographs to generate historic change maps of riparian condition, maps of stream channel change, and to corroborate age estimates of woody riparian vegetation (cottonwoods and willows).



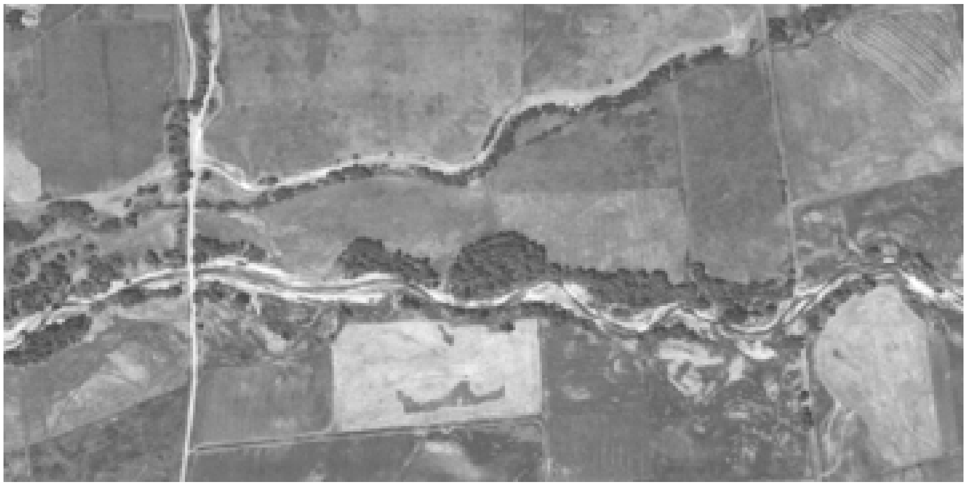


Figure 1. Historic aerial photographs of the Little Bear River, Utah, flow is from left to right. Upper image is from 1953 and lower image is from 1959. Note loss of riparian vegetation downstream (right) of bridge crossing and expansion of gravel deposits in the stream channel.

Field (Site) Scale

Field data incorporated into the GIS typically involves topographic or vegetative surveys, point data from stream or water quality monitoring, and hydrologic data from USGS gaging stations or field based water-level recorders. Repeat surveys of stream channel cross-sections at monitoring sites are being used to determine the nature of channel change at specific sites. These survey data are stored within the GIS environment.

Additional site data include ages of cottonwood trees at selected sites along the main stream valley. The relative location of these trees are determined from field surveys. Field survey data are then geo-referenced in the GIS by establishing coordinates for local benchmarks or known points in the area using a Global Positioning System (GPS).

Water quality data for long-term monitoring sites are recorded as point data within the GIS. These data can be accessed from the GIS in tabular or graphic form. A suite of water quality parameters are available in these forms. Historic trends can be evaluated with regard to changes in land management activities upstream of the monitoring sites.

Finally, we have a historic record of site conditions based upon repeat photo points (ground level oblique photographs). These photos are available as a catalog of data depicting changes in hillslope or stream conditions. Although qualitative, these photographs provide powerful visual information regarding historic trends at a particular site.

GIS for Water Quality Management

The GIS we have developed here can be used to improve decision making and management regarding water quality issues in the study watersheds. As an example, it is possible to evaluate potential restoration sites with regard to upstream conditions (cumulative impacts) as well as local conditions (riparian or stream condition). Combining watershed based estimates of wetness with reach based estimates of stream power yield maps that can be used to assess restoration potential along a stream channel. Low values for stream power and high wetness indices represent high potential whereas high stream power and low wetness would indicate low restoration potential.

Reach based estimates of total or specific stream power also can be used to evaluate potential sources of sediment entering the river system. For example, if bank material strength is considered constant through a large reach, changes in specific stream power could indicate greater potential for erosion and therefore greater source potential for sediment. to enter the stream. Riparian conditions then can be evaluated in these areas to determine if revegetation would decrease sediment delivery to the channel.

Use of historic aerial photographs and multispectral videography provide us with tools to evaluate the nature and extent of changes along the stream and riparian corridor. We evaluate changes at sites or along reaches relative to historic flow conditions (recent or historic floods) and land management strategies. Where possible, we attempt to assess the role of floods in changing stream and riparian conditions. In particular, we are developing a model that considers hydrologic and geomorphic conditions necessary for cottonwood regeneration. These temporal tools provide a means to evaluate conditions within a larger historic context.

Summary

GIS provide powerful tools for spatial and temporal data analysis at the watershed, reach, and site scale. Use of modeling tools available within GIS provide a means to link water quality conditions at specific points to cumulative effects from upstream environments. Historic data also provide a framework for evaluating rates of change in stream or riparian conditions.

Acknowledgments

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Using a Geographic Information System to Identify the Chesapeake Bay Watershed's Strategic Agricultural Land: Why is it Necessary and How is it Done?

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American Farmland Trust, Washington, DC

The Chesapeake Bay watershed, a spider web of rivers and streams weaving through six states, is a lifeline to the Chesapeake Bay. For the bay's diverse population of plant, animal and marine life, the waterways draining into the bay represent a food source, spawning area and shelter.

The same watershed represents home to more than 13 million people. To accommodate the masses, residences and businesses are constructed, roadways are paved, and sewer systems are built between the watershed's northern tip in New York and its southern tip in Virginia. Collectively, this development places a strain on the bay area's natural resources.

One of those resources is agricultural land, whose benefits include:

- High quality food production.
- Ecosystem maintenance, restoration, and enhancement.
- Protection of historic landscapes, scenic beauty, and open space.
- Economic stability of communities.

- Sustainable rural development.

Within the watershed, as well as the country, Maryland is arguably the leader in protecting agricultural land. In 1977, Maryland created the first statewide purchase of development rights program. Through the PDR program, landowners are compensated for voluntarily agreeing not to subdivide or develop their property. More than 117,000 acres of Maryland's agricultural land is permanently protected under the state's PDR program, and nine county-level programs that have been implemented since the state program began.

Despite Maryland's successes, the state is struggling to protect farmland from the checkerboard pattern of development called urban sprawl. For every one acre of agricultural land Maryland protects, it is losing two acres of farmland (approximately 20,000 acres) annually. With the watershed's population expected to increase 20 percent in the next 25 years, the Governor's Commission on Growth in the Chesapeake Bay Region anticipates that this ratio will increase if traditional development patterns do not change. The commission anticipates that almost one-third (695,000 acres) of the state's farmland and forestland will be converted to non-agricultural use during that time period, leaving 1.6 million acres of farmland.

Maryland is not the only state facing this struggle. The ratio of farmland lost to that protected is similar, if not worse, in most of the states that are part of the watershed. This suggests that, although PDR is an effective farmland protection tool, it is not enough in an era when growth pressures are increasing. In this climate, public and private entities should be challenged to take a more innovative approach to protecting farmland.

To ignore this challenge would be irresponsible, both from a local and a national standpoint. According to a 1993 study by American Farmland Trust, Farming on the Edge, the mid-Atlantic/Chesapeake Bay area is the fourth most threatened agricultural area in the United States. In selecting the area for its list of "The Top 12 on the Edge," AFT cited the region's economic importance as a food-producing area and the threat to its agricultural resource base from rapid population growth and urban-edge sprawl.

Ignoring the challenge would be irresponsible, too, since the Chesapeake Bay is the nation's largest estuary and it is a treasured resource for those who visit it once a day or once a lifetime.

The Solution: Identify Strategic Farmland

The threat to the watershed's agricultural land and, ultimately, the bay, can be minimized if a more strategic approach to the protection of farmland is implemented. Utilizing a strategic approach recognizes that time, money and energy are limited, so one must be more selective in deciding which farmland to protect. Some farmland should be developed for housing and commercial uses, while some_not all_should remain open and available for food production and other public values. Most state and local farmland protection programs do not have a strategic plan. Incentive-driven programs, such as PDR programs, use criteria to set ad hoc priorities among those who want to participate. Regulatory programs, e.g., planning and zoning, circumscribe the general area where farmland protection policies apply. But few actually attempt to identify their most important farmland, determine how much of it needs protection, or set specific objectives for protecting the land.

Using a strategic approach to identifying farmland also recognizes that agricultural land is important for a variety of reasons. Since farmland protection programs were created two decades ago, food production has been the rationale for retaining land in agricultural use. With this focus, prime, unique, and important farmland is the priority for PDR and other farmland protection programs. A strategic approach identifies farmland that is important to society not just for food production but as a multiple-purpose resource. Farmland may be strategic, for instance, for environmental, economic or cultural reasons, too.

The Method: Geographic Information Systems

The most effective, reliable and simplest way to map strategic farmland is to use a geographic information system. Made up of hardware, software and graphics, a GIS can encode, analyze, and display multiple data layers. Information about property ownership, assessment and taxation, for instance, can be directly related to water resources, soils, agricultural productivity, wildlife habitat, and historic sites. The integrated data can be presented in tabular, graphic, and map format. By integrating data, a GIS provides the framework for better understanding the spatial and temporal interrelationships of landscapes.

On a national level, AFT used GIS in 1993 to produce a map of the country's strategic agricultural land. On a state level, Maryland and Delaware are the first areas undergoing this paradigm shift. Both states hug the bay.

In the watershed, implementing a strategic approach has several implications for the health of the bay's ecosystem. Among them is that the environmental benefits of farmland are elevated to a higher level when farmland is prioritized. Environmental amenities include the retention capacity for floodwaters, the conservation of soils, the protection of water quality and the enhancement of wildlife habitat.

In 1995, Delaware became the first state in the country to map strategic agricultural land. Factors mapped were soils, land use/land cover, sewer districts, agricultural investment, percentage of crop areas, and existing and proposed natural and open space areas. The Delaware Agricultural Lands Preservation Foundation's Agricultural Lands Strategy Map was a key factor in Governor Thomas Carper's decision to earmark $12 million for the state's PDR program, the first such appropriation since the program's establishment in 1991. The map is being used to prioritize which land to protect through the program.

The Future Harvest Project

Maryland is following suit. Under the direction of AFT and the Chesapeake Bay Foundation, a map of strategic farmland in the Maryland portion of the watershed (approximately 95 percent of the state) is being created. The Delaware portion of the watershed (approximately 30 percent of Delaware) also is included. The mapping project, due to be completed by the end of 1996, is part of the Future Harvest Project: Farming for Profit and Sustainability, a W.R. Kellogg Foundation-funded initiative designed to foster the widespread adoption of sustainable agriculture in the Maryland and Delaware portions of the watershed. AFT, CBF and eight other groups and individuals from the farming and environmental communities are carrying out the Future Harvest Project.

The first step in creating the map was to identify the type of data to use. Several brainstorming sessions were held by the Chesapeake Farms for the Future Board, the board created to assist AFT and CBF in completing this project, to determine what data is most important in the watershed. Through this consensus-building process, the board agreed that the following factors define strategic farmland in the watershed (items in parentheses indicate the specific categories of information to be used):

- Land Cover (agricultural, forest, development).
- Soils (prime/productive, unique, other).
- Productivity (market value of production, microclimate, profit/income).
- Farm Viability (agricultural infrastructure, on-farm investment, leased vs. owned farms).
- Development Pressures (population growth projections, recorded subdivisions, designated growth areas, sewer service areas).
- Protected Lands (agricultural zoning areas, easements, public lands, sending areas for transferrable development rights programs).
- Cultural Implications (historic sites, scenic roadways).
- Environmental Implications (endangered and threatened species habitat, watershed boundaries, wetlands).

Databases containing this information will be acquired or provided for no fee from various sources, primarily the Maryland Office of Planning, Maryland Department of Natural Resources (Maryland Heritage Program), and United States Department of Commerce (Census of Agriculture). Most of this data is digitized and available in Arc/Info format. The project's GIS consultant will then input this data into a GIS. A challenge during this phase will be making the databases compatible so the edges of the various maps (each containing different information) match.

The result will be a series of county- and state-specific maps, each at a scale of 1:24,000 and color-coded to highlight the most strategic agricultural land. Each map will contain a base layer which includes the limits of the watershed, state, county and city boundaries, major water bodies and roads. Also produced will be charts and tables which summarize the data from those maps. The products will be available to public and private entities and individuals for their use in making planning, land use and other decisions involving the watershed. For groups, particularly those at the county level, operating with limited time and money, the map and database are expected to be invaluable resources.

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Implementing a Watershed Management Program Using GIS

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This paper describes five applications of a Geographic Information System (GIS) used in the implementation of the Watershed Management Program in Prince William County, Virginia. The GIS software used in the county is ARC/Info of the Environmental Systems Research Institute (ESRI). The following applications are described:

- Drainage System Inventory and NPDES Compliance.
- Watershed Modeling Automation.
- Inventory of Natural Resources.
- Watershed Management Strategy Selection.
- Storm Water Management Fee.

These applications allow the county to manage large amounts of data and to communicate the results of watershed studies and watershed management activities to the public, elected officials, and regulators.

Drainage System Inventory and NPDES Compliance

The county conducts inspections and maintains approximately 250 storm water management (SWM) facilities and 130 miles of drainage easements. These easements include drainage ditches, pipes, inlets, storm water management facilities, and other drainage structures.

The GIS based drainage system inventory contains information on the SWM facilities and drainage structures located in the easements. The information in the inventory includes the size, location, and type of storm water or drainage structures; the invert elevations of drainage structures; and other facility specific data.

The drainage system inventory was developed to facilitate the inspection of drainage easements and maintenance activities. The maps produced with the inventory are used by maintenance crews to locate pipes and drainage structures during inspections. A process was developed to update the maps regularly. An inspector provides feedback when discrepancies are noted between what was shown on the map and what was actually observed in the field. The maps have also proved valuable to locate outfalls during emergency cleanup of spills of hazardous materials.

The drainage system inventory also provides information on the location and type of storm water outfalls. This information is used in the preparation of watershed studies and permit applications for compliance with EPA's National Pollutant Discharge Elimination System (NPDES) program. The inventory was used to identify some of the outfalls that meet the NPDES regulatory requirements. Since the inventory was incomplete during the preparation of the NPDES applications, paper maps and site visits were also used to identify outfalls.

The GIS was used to depict the results of NPDES pollutant field screening at 265 major outfalls. The maps prepared helped to visualize the types of problems and the spatial distribution of potential sources of nonstormwater discharges.

Watershed Modeling Automation

Watershed models are used to study the hydrologic and hydraulic characteristics of the County's 32 watersheds, and to design facilities that will mitigate floods, control erosion, and improve water quality. The preparation of the input parameters for these models involves overlaying land-use information, soil types, topographic and hydrographic features, and pollutant loading rates. This process, typically done by hand, is extremely time consuming.

The GIS is used to automate the preparation of the input parameters for the HEC-1 and HEC-2 models. This application expedites the development of watershed models and allows the analysis of alternative solutions and "what-if" scenarios. This application was tested in three watersheds covering approximately 80 square miles. In the future, this application will be used in the remaining 29 watershed management areas.

The process to automate hydrologic models (such as HEC-1, TR-20, or PSRM) involves creating soils, land use, and subwatershed boundaries, and assigning attributes to each coverage such as hydrologic soils groups (HSG) and TR-55 land use classifications. The process then involves overlaying the coverages, computing Runoff Curve Numbers (RCNs) for each polygon in the "combined" coverage based upon HSGs and land use and then computing a composite RCN for each subwatershed. The RCNs provide a means to compare the relative runoff potential of various watershed areas. An automated macro language (AML) or macro was developed was developed to automate this process and facilitate future applications.

The next step in the automation process of hydrologic models involves the computation of the time of concentration (TC) for each subwatershed. TC is the time for the runoff to travel from the hydraulically most distant point of the watershed to the point of interest. A macro was developed to use the topographic analysis tools available within the ARC/Info GRID package. The macro applies elevations from the Digital Elevation Model (DEM) to overland and sheet flow, obtain slope and, in turn, travel times. The TCs for shallow concentrated flow and channel flow are calculated using the flow line coverage and supporting look-up tables.

The GIS is also used to compute non-point source pollution loads based on land use, soil type and available areal loading rates. Local loading rates based on monitoring data and literature values available from the National Urban Runoff Program (NURP) were used. The GIS tool delineates and calculates any drainage area using a digital elevation model.

Inventory of Natural Resources

The GIS is being used to collect and depict wetlands data and biological monitoring data. The data is being collected as part of a multi agency watershed management demonstration project. Trend analysis and establishment of performance measures for several watershed management strategies are planned with the inventory.

The county also used the GIS to compile Chesapeake Bay Resource Protection Area (RPA) boundaries. The RPAs are areas that if improperly developed will cause a significant impact on water quality. Paper sources were used to create layers such as soils, floodplains, perennial streams, and wetlands. Developers use RPA maps in order to plan future development.

Watershed Management Strategy Selection

The GIS will be used as a decision making tool to identify applicable management strategies. The process involves developing a composite layer by overlaying hydrologic and hydraulic data, and information on environmental resources (wetlands, highly erodible areas, steep slopes, streams, flooding, bioassessments, water quality, etc.). The composite layer will identify, by color, the environmental sensitive areas, the impaired waters, and the source of the environmental problem. A menu of control strategies will assist in determining where to concentrate the management efforts.

Storm Water Management Fee

The County used the GIS to determine impervious areas (rooftops, paved areas, etc.) of approximately 80,000 parcels and to calculate the "base unit" for the storm water management fee. The base unit is the total impervious area of a typical single family residential property in the county. The base unit in the county equals 2,059 square feet.

The county-wide stormwater management fee is based on each parcel contribution to storm water runoff. The amount of runoff is proportional to the parcel's impervious area. The GIS data was used by a storm water assessment system to calculate storm water management fees for all parcels.

Summary

Prince William County has had the foresight to realize the long-term flexibility and cost savings afforded by coordinating GIS applications with the implementation of the Watershed Management Program. The county is also using GIS to communicate the progress being made in the protection of its water resources and to facilitate compliance with state and federal regulations.

Implementing Watershed Protection Projects Using Principles of Marketing

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The United States Department of Agriculture Natural Resources Conservation Service (NRCS) has worked with the National Association of Conservation Districts and National Association of State Conservation Agencies to develop an effective procedure for implementing watershed protection projects under a variety of conditions. Smaller budgets and a wider diversity of private landowners, land users, and persons interested in watershed protection requires more creativity in how we work with people to manage the bio-physical resources, as well as the human component, of the watershed ecosystem.

Using principles and concepts of marketing, proven effective in industry and business for influencing people's behavior, the NRCS has developed and is testing conservation marketing for implementing watershed protection projects. The purpose of this paper is to introduce the NRCS conservation marketing process being used to actively encourage voluntary participation in Soil and Water Conservation District and NRCS watershed protection projects on privately owned lands.

The case study used to illustrate conservation marketing comes from Mission-Lapwai Creek Watershed in northern Idaho. The project sponsors and the NRCS field staff were committed to insuring that landowner needs were investigated and considered as the project to restore anadromous and resident fisheries habitat on private lands was implemented. Project sponsors and staff used NRCS's conservation marketing process as a means to develop a strategy that would fulfill this commitment and allow them to successfully achieve the project's watershed protection goals.

Conservation Marketing

Mention marketing and some people immediately see a smooth-talking used car salesman in a plaid sport coat haranguing customers with a high-pressure sales pitch. Others will think it another management trick to get more work out of fewer people. NRCS's conservation marketing, however, has nothing to do with these old cliché images. Conservation marketing is not forcing unwanted government programs and projects on skeptical landowners. Instead, conservation marketing involves identifying landowner needs and developing a watershed protection plan which meets their needs, as well as the bio-physical needs of the watershed.

Conservation marketing is designed to help NRCS Field Offices, local Soil and Water Conservation Districts (SWCD), watershed steering committees, coordinated resource management planning (CRMP) groups, and other concerned individuals and groups develop watershed protection plans which include socially acceptable land management conservation practices and management systems.

The conservation marketing is a relatively straightforward process. Although conservation marketing is not a linear process, it roughly follows seven steps:

- Identify the Critical Issues.
- Develop Alliances and Determine Your Role.
- Define Customers.
- Identify Customer Needs.
- Set a Strategy and Action Goals.
- Develop and Initiate the Marketing Plan.
- Evaluate the Marketing Effort.

Mission-Lapwai Creek Watershed Protection Project

The Mission-Lapwai Creek Watershed Protection Project in northern Idaho's Lewis and Nez Perce Counties provides a case study example of how conservation marketing is being used to motivate landowner participation. The project is intended to move the two creeks toward compliance with the Clean Water Act's goal of fishable and swimable waters, and comply with all applicable water quality standards. The project calls for accelerated land treatment and non-structural management practices on non-irrigated cropland and riparian zones located adjacent to Mission and Lapwai Creeks. The voluntary cooperation of the watershed's 73 farmers and ranchers is critical to reaching the project goal of treating 75% of the damaged riparian area (about 12.2 miles or 43 acres) and applying treatment measures on 75% of the project area's cropland (26,180 acres).

The original Implementation Plan included in the Mission-Lapwai Creek Watershed Project consisted of two sentences stating that the NRCS field office staff and sponsors:

"The sponsors will encourage the development and application of long term contracts on all identified cropland and riparian areas needing treatment. They will provide leadership through an aggressive information and education program to encourage application of land treatment and nonstructrual measures necessary for the success of the project." (Supplemental Watershed Protection Plan-Environmental Assessment, Mission-Lapwai Creek Watershed, Lewis and Nez Perce Counties, Idaho, 1994, p. 19).

It was implied that project sponsors and staff should get every land owner of critical riparian areas in the watershed to participate in the project and that you merely need to educate landowners to get them to sign long term contracts with the government that could cost them thousands of dollars and change the way they farm or ranch. Since these landowners were not a homogeneous group and their operations were also run differently, this simple, ungrounded approach to encouraging project participation was bound to be ineffective in its outcome, frustrate the project staff, and waste a lot of time and money. The field staff realized the problems they would face if they pursued this approach and decided to use conservation marketing to recruit the participation required for project success.

Conservation Marketing Plan for Mission-Lapwai Creek Watershed Protection Plan

A group of people representing the project sponsors, technical staff, and others who had an interest in the project or knowledge of the operators and operations in the watershed area were brought together to provide information necessary for developing the marketing plan. The group determined that there were two critical issues on which the marketing plan needed to focus: (1) Overcoming land owner and operator reluctance to work with NRCS to restore anadromous and resident fisheries habitat, and (2) Improve the habitat of the anadromous and resident fisheries. The group then identified specific actions which need to be done to resolve these issues. This becomes the fundamental goal of the marketing plan.

Following the conservation marketing steps the group decided what the role of the project sponsors should be in addressing the critical issues. Next they identified about 15 to 20 other individuals, groups, and organizations which have a stake in these issues, can help resolve the issues, and have something to gain from these issues being resolved. The last thing the group was asked to do was to identify and profile critical watershed area landowners and their operations. The profile included the group's perception of landowner needs and concerns, landowner sources of information, their decision making process, and a listing of those that influence their decisions or whom landowners trust when making a decision.

This information was then validated through a series of personal interviews with landowners. Corrections, additions, and deletions were made and, subsequently formed the basis for the Mission-Lapwai Watershed's Conservation Marketing Plan's strategy, goals, and plan of work.

Considering the abilities and the limitations of the project sponsors and field staff available to implement the project's marketing plan, a modified version of the conservation marketing model was used. Due to time constraints, it was decided that initially a marketing plan for only the project's first year of implementation would be drafted. The critical issues identified at the outset remained unchanged. Developing alliances was not determined to be a priority at the early stages of implementation and it was decided to postpone this task until two or three successful demonstration projects were completed.

In the first year of implementation six farming and ranching operations in critical areas in the watershed were targeted. These were chosen based on bio-physical needs, potential for signing an agreement, and the potential for the land management practices (i.e., cropland treatments and nonstructural measures) to visibly demonstrate positive results and, thereby, influence other landowners. For each operation a customized marketing strategy was drafted. The strategy consisted of identifying and profiling each operation's decision maker(s) and their concerns and needs; determining precisely what landowner action was desired; concluding what the possible landowner benefits were to participation in the project; and devising the specific actions to be taken to persuade and motivate landowner cooperation.

Outcomes and Lessons Learned

In the first four months of using the conservation marketing approach to implement the Mission-Lapwai Creek Watershed Protection Plan, two landowners have signed long term contracts. One contract is for a water and sediment control structure and the other is for riparian area management and restoration.

The most substantial advantage field staff noted for using a marketing plan to implement the project is that it saves them time and effort by identifying who would be most productive to contact, how they should contact them, and what would be the benefits of project participation to this particular landowner or operation. Other advantages noted were that:

- A marketing plan sets realistic goals for recruiting voluntary participation and provides guidance for accomplishing those goals.
- By taking into account the social conditions of the watershed, a marketing plan communicates to an organization's administrative levels significant controlling factors which influence implementation.
- Conservation marketing, by requiring that we talk to landowners before we try to persuade them to commit to a watershed protection practice, demonstrates our respect for the landowner, their needs, and the viability of their operation.

The following suggestions for improving the usefulness of conservation marketing were provided by field staff and project sponsors:

- Include conservation marketing considerations at the beginning of watershed protection planning, not just when it comes time to implement it.
- Involve potential targeted landowners in the initial stages of watershed protection planning so we have to make fewer assumptions in the marketing plan regarding social acceptability of project goals and possible solutions.
- Include project sponsors, landowners, and stakeholders in writing and carrying out the marketing plan.
- Use the marketing planning process as a tool to evaluate the chances that voluntary participation will be adequate to reach the watershed plan's resource management objectives, and/or to indicate what it is going to take to get the necessary participation levels.
- Institute conservation marketing (and the consideration of social conditions) into watershed protection planning so that it carries enough weight to justify the commitment of more resources to implementation.

Conclusion

Applying principles of marketing to the implementation of watershed protection projects provides planners a practical means to develop plans people want and need; not plans which we have to coerce, legislate, bribe, or otherwise bully people into using. The linchpin to successfully marketing watershed protections projects on private lands is to convincingly demonstrate to landowners how project participation will meet their needs or solve their problems. The conservation marketing process NRCS is testing provides a tool for doing this by requiring that planners consider landowner concerns, needs, and problems as they identify resource problems and select alternatives to solve these problems.

Building Capacity For BMP Compliance: An Applied Behavioral Analysis

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Over the last two decades, water quality researchers have conducted numerous field and laboratory studies to identify effective techniques to prevent or reduce contamination of water resources. However, a critical issue that is not addressed in most of those field and laboratory studies and associated guidance documents is how to ensure that the improved pollution prevention and control technologies are adequately implemented (US EPA, 1993). To be effective, our environmental programs and regulations must eliminate, reduce or adjust behavior that degrades the environment. However, comparatively little research has focused on identifying the most effective ways to accomplish that end.

Numerous scholars and study commissions have argued for greater research on ways to promote environmental regulatory compliance because of the great potential that this work offers for improving the effectiveness of our environmental protection programs (Andrews, 1992; U.S. EPA, 1990; Geller, 1992 & 1989; Russell, Harrington, and Vaughan, 1986; Draggan, Cohrssen, and Morrison, 1987). If researchers can develop a thorough understanding of enforcement activities that promote environmental regulatory compliance, then agencies can use that information to tailor appropriate responses to specific compliance problems. In the ideal situation, agencies would know all the important cause and effect pathways, the threshold levels for effects, and the costs and benefits of alternative management approaches. In short, we could design the perfect cost-effective program to ensure progress toward environmental goals (Sparks, 1987).

This paper reports on research that begins to answer some of those important questions as applied to urban erosion and sediment pollution control practice (UESC). The study relies on a recently neglected but arguably useful theoretical framework for identifying effective enforcement actions to advance compliance with UESC regulations_namely, applied behavioralism. The next section describes the study methods and data collection procedures. This is followed by a presentation of the study results with discussion of how the findings square with the applied behavioralism literature as well as other socio-behavioral theories. The article concludes with a discussion of the study limitations and future research needs.

Enforcement Intervention: What Works?

The social science literature that is relevant to the study of environmental regulatory compliance is rich and vast. There are a multitude of explanatory frameworks that researchers can use to guide investigations of environmental regulatory compliance, including models based on economic theory (Stover and Brown, 1978), deterrence theory (Braithwaite and Makkai, 1991), social control theories (Hirschi, 1969; Reckless, 1967), and subculture theories (Bardach and Kagan, 1982; Braithwaite, 1989) to name just a few. One of the more interesting but often overlooked explanatory frameworks is that of applied behaviorism (Geller, 1992).

The behavioralist approach seeks to develop parsimonious explanations of overt behavior through quasi-experimental studies that avoid making assumptions about a target groups' cognitive deliberations to the greatest extent possible (Tallman and Gray 1990). Applied behavior analysts (ABAs) acknowledge that those cognitive processes (which are often the explanatory linchpins of many of the aforementioned competing behavioral theories) are interesting and concede that certain cognitive deliberations and attitude change may be important for inducing regulatory compliance in some settings. However, ABAs consider those inferred cognitive activities to be of secondary significance to gaining practical, applied understanding of interventions that reliably produce the desired behavior change. In short, ABAs argue that it is most cost-effective to apply intervention strategies directly to the relevant behaviors rather than attempting to understand what are the key cognitive deliberations, attempting to modify those cognitive calculations and then hoping for a subsequent indirect influence on behavior (Geller, 1990).

Applied behavioral analysts directly test environmental arrangements or stimuli (antecedents and consequences) posited to increase the occurrence of desired behavior or reduce undesired behavior. In this application, focusing on the UESC context, some of the compliance supporting stimuli or key antecedent characteristics tested include: the duration and intensity of surveillance, technical assistance efforts (e.g., pre-construction conferences and use of design professional oversight) and communicative clarity. In addition, since operant learning results from behavioral consequences, other salient factors to test for include prior enforcement experiences that reinforce expected rewards for compliance or that punish noncompliance.

Data and Method

The data used in this analysis were generated from a comprehensive evaluation of North Carolina's Erosion and Sedimentation Control Program, which was commissioned by the N.C. Department of the Environment, Health and Natural Resources (see Malcom, et al., (1990) for full study results). Under the

North Carolina Sedimentation and Erosion Control Act all construction projects of one acre or more must submit and receive approval of Pollution Prevention Plans (PPPs) to ensure that the Act's goals will be met. A quasi-experimental, post-test design (Rossi and Freeman, 1988) was used to evaluate program performance. The unit of analysis is construction projects, with the study population consisting of all construction projects falling under the program's jurisdiction during the summer of 1989 when the field research was conducted. A stratified random sample of 128 construction projects were evaluated for compliance with the Act's requirements. For each construction project in the sample, variables were measured using four data collection procedures. The degree of compliance with the PPP requirements was measured in the field through site visits to each of the 128 projects in the sample. Other measures to control for variability in project characteristics and enforcement stimuli were taken from the field survey and surveys of staff, project developers and project files. OLS regression analysis is used to evaluate the effects of enforcement stimuli and antecedents on installation compliance while controlling for site characteristics. Logistic regression analysis is used to evaluate the same predictors for the performance compliance measure.

Two indicators provide measures of compliance with the Act's standards: (1) the percentage of BMPs specified on approved PPPs that are actually installed at a construction site, and (2) whether there was no major loss of sedimentation off-site or into adjacent waterbodies. All of the site characteristics measure important aspects of the regulatory task's tractability which need to be statistically controlled for in the multivariate analyses. Surveillance of the project site was measured in terms of both frequency and duration. Communicative clarity is measured on a five-point scale (i.e., engineer's perception of the clarity of the erosion and sediment control plan). Inspector expertise is measured in years of experience since most of North Carolina's inspectors gain expertise through what is equivalent to an apprenticeship process (Paterson, 1989). Dummy variable indicators are used to note whether design professional oversight was required as a condition of project approval and whether a pre-construction conference was held before land disturbing activity commenced. Prior enforcement experience is measured by information reported by the project developer and inspector. A dummy variable indicates whether a sediment control agency has imposed a fine, stop work order or restraining order, or revoked a grading permit because the developer failed to comply with the Act's requirements at any time over the preceding three years (based on self-report from the project developer). A dummy variable is also used to indicate situations where the developer and inspector worked together on prior projects and where both parties were willing to characterize that past working relationship as cooperative.

Results

Table 1 on the following page reveals that both models are statistically significant at the .05 level or less. The predictors explain about 22 percent of the variation in the installation compliance model (Adjusted R-squared). While many of the predictors are in the hypothesized direction, only a few variables attain the .05 level of statistical significance. Controlling for site characteristics, the two key predictors for the installation compliance model are PPP clarity and an established cooperative rapport between the inspector and developer. Installation compliance was, on average, about 17 percent greater at projects where prior enforcement experiences had engendered a cooperative rapport as opposed to those with no prior cooperative enforcement experience to build upon (holding all other predictors constant). Several of the enforcement inputs are statistically significant predictors of the log likelihood of performance compliance, including PPP clarity, inspector expertise and whether a pre-construction conference had been held. As in the installation compliance model, an established cooperative rapport is also a statistically significant predictor of the log likelihood of performance compliance.

Table 1. Factors Affecting Compliance with Nonpoint Pollution Control Regulations

	Compliance Indicators (1)	
Variable	**Installation (Coef) (Sig)**	**Performance (L.Odds) (Sig)**
Site Characteristics		
Acreage Disturbed	.15 (.31)	-.01 (.38)
Residential Project	-1.60 (.35)	1.63 (.00)*
Phase of Grading	10.14 (.00)*	.26 (.15)
Mountain Region	13.50 (.04)*	-1.85 (.00)*
Piedmont Region	21.89 (.00)*	-1.77 (.01)*
Project Enforcement Inputs		
Surveillance:		
Inspections per month	.55 (.18)	-.10 (0.7)
Time per inspection	.12 (.25)	-.01 (.25)
Communicative Adequacy:		
PPP clarity	5.77 (.00)*	.56 (.00)*
Technical Support:		
Inspector experience	.59 (.31)	.51 (.00)*
Preconstruction conference	1.24 (.40)	1.74 (.00)*
Engineering oversite provided at site	-10.45 (.07)	.63 (.20)
Prior Enforcement Experience		
Cooperative Rapport	16.61 (.00)*	1.56 (.01)*
Sanctioned w/in 3 years	-16.75 (.00)	.25 (.35)
R-Squared	.317	Pseudo .218
Adjusted R-squared	.217	Log-L -46.72
F-value	3.173	ChiSq 41.05
Degrees of Freedom	13,89	13,89
Significance	.001	.000

(1) Significance levels for coefficients are based on one- tailed test.

Discussion

The findings reported here are consistent with prior research reported from the applied behaviorism literature. First, the importance of the PPP clarity measure is consistent with prior empirical findings that communications about desired behavior must be clear and precise (Geller, 1992). Second, inspector expertise and the pre-construction conferences may also serve to ensure that clear and precise regulatory requirements are conveyed as well as providing those messages in close proximity to opportunities to change the target behavior (e.g., clarifying expectations in the field, rather than going back to an office for advice or sending a formal written notice of violation that fails to ensure understanding of specific problems). Moreover, the pre-construction conference tends to be a participatory process rather than a formal command approach which also has been shown to improve behavior change (Geller, 1989). Finally, the cooperative rapport finding and the failure of formal sanctions to elicit compliance is also consistent with prior behaviorism studies. Rewards are considered superior consequences in many instances because they have a greater chance of engendering positive attitudes toward the desired behavior from the recipients. This, in turn, increases the possibility of the desired behavior becoming a norm (i.e., a socially accepted rule of action). A cooperative rapport enables the inspector to overlook small violations in return for the developer being consistent in ensuring that no major violations occur. This can only occur through the development of shared understanding and mutual trust through repeated interactions. By contrast, negative consequences such as formal sanctions tend to require continual application and may also elicit negative attitudes and rebellion behavior (Geller, 1989).

Conclusion

The ABA framework is a potentially powerful guide for improving environmental regulatory compliance. While its greatest use to date has been in largely voluntary environmental settings, the present investigation points to its potential usefulness in regulatory settings as well. There are countless possibilities for quasi-experimental designs to test the influence of various enforcement efforts on compliance that could be carried out at minimal expense within existing environmental programs. However, while the U.S. EPA has expressed some interest in this area (US EPA, 1990), commitment to environmental protection behavioral research remains largely nonexistent in most federal and state programs (Andrews, 1992; Geller, 1989). Significant advances in environmental protection behavioral research will only occur when environmental management, enforcement and research communities work more collaboratively to address program effectiveness concerns (Draggan, Cohrssen, and Morrison, 1987).

Maryland's Tributary Strategies: Statewide Nutrient Reduction Through a Watershed Approach

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Origins of the Program

Maryland's Tributary Strategies are a recent addition to the historic Chesapeake Bay Agreement, signed in 1987 to address the problem of overenrichment in the nation's largest and most productive estuary. In 1987, Maryland, Virginia, Pennsylvania, the District of Columbia, the Environmental Protection Agency, and the Chesapeake Bay Commission (the Executive Council of the Chesapeake Bay Program) formally agreed to work together to achieve a 40% reduction in nitrogen and phosphorus reaching the Bay by the year 2000 (using 1985 as a base year).

Extensive scientific studies had identified excess nutrients as the primary pollution problem in the Bay. High levels of nutrients cause excess algal growth, depleting dissolved oxygen in the water as it decomposes, and reducing the amount of habitat for animals. In addition, algal growth blocks the sunlight needed by beneficial bay grasses, which provide food and habitat to waterfowl, fish and crabs. The 40% level was estimated by Bay scientists as the reduction necessary to significantly improve dissolved oxygen in the deep waters of the Bay, triggering a series of beneficial responses in habitat, and benefitting living resource populations.

In 1991, the Chesapeake Bay Program conducted a scientific re-evaluation to assess progress toward the 40% goal. It concluded that, although significant progress had been made through a ban on phosphorus in laundry detergent, and upgrades at wastewater treatment plants, more needed to be done to control nonpoint sources. As a result of this finding, in 1992, the Executive Council directed all the Bay partners to develop "tributary strategies"_watershed-based plans to reduce nitrogen and phosphorus entering the Bay's rivers.

The Approach

In Maryland, the goal of the Tributary Strategies was to introduce a new working relationship between the federal, state and local governments, business, the agricultural community and citizens to improve water quality, and enhance habitat for living resources. Just as the Chesapeake Bay Agreement is a model for interjurisdictional cooperation, the state recognized a need to extend this partnership to those responsible for making local land use decisions. To initiate and manage this process, State agencies involved in natural resources management formed a steering committee on the Tributary Strategies. Comprised of staff from the Departments of Environment, Natural Resources, and Agriculture, the Office of Planning, the University of Maryland. and the Governor's Office, the committee worked to ensure a coordinated approach among all the agencies responsible for planning and implementing this complex program.

Because over 95% of Maryland's land area is in the Chesapeake Bay watershed, meeting the 40% goal demanded a comprehensive, statewide approach. In order to address regional land use and water quality issues as part of its nutrient reduction strategy, Maryland divided its Chesapeake Bay watershed into ten tributary basins. The state then conducted a two-year, three stage effort incorporating technical analysis, document production, and formal and informal meetings with local governments and the public meetings at every stage. During the first stage, each of the ten tributary basins was characterized in order to describe the pollutant loads, sources, and reduction goals; land uses; and the status of fish and wildlife populations. The second stage involved assessing all of the options for nutrient reduction, such as biological nitrogen removal at wastewater treatment plants, erosion and sediment control on construction sites, agricultural nutrient management, and streamside forested buffers. For each option, information was gathered on costs, applicability and implementation considerations. The third stage involved setting numeric targets for implementing the most promising options identified in stage two, based on past levels of implementation, cost, acceptability, and comments from the public and local governments.

Moving Toward Implementation: The Tributary Teams

To help implement these Strategies, "Tributary Teams" were formed in each of the ten watersheds. These teams are made up of representatives of state and local agencies, farmers, business, environmental organizations, federal facilities, and citizens. They meet monthly, providing local knowledge essential for implementing best management practices, and helping state and local governments target their programs to improve efficiency and participation.

The Teams were charged with:

- Ensuring that implementation proceeds on schedule in a fair and flexible manner;
- Coordinating participation among citizens, government agencies, and other interested parties; and

- Promoting an understanding of Tributary Strategy goals and the actions needed to achieve them through public education.

Most Team members were selected from individuals who nominated themselves at the public meetings. However, additional Team members were recruited to ensure balanced representation of all stakeholder groups. In order to share the heavy workload involved in working closely with the Teams, different state agencies agreed to act as the lead for one to three Teams. The Lead State agency designates a staff person as a Team member, and represents all State agencies on the Team. In addition, two Team coordinators were hired to provide organizational and staff support for all ten Teams. Team lists were drafted by an ad hoc committee of local government and state agency staff. These lists were then sent to local elected officials for their review and comment, and finally to the Governor for formal appointment. The Teams were appointed by the Governor in August 1995. They first met in September 1995, and continue to meet monthly.

Progress To-Date

Progress on the ground. Maryland's Tributary Strategies lay out ten implementation plans that will be accomplished between 1994 and the year 2000, and builds on implementation efforts that began in 1985. Significant progress has been achieved since the Strategies were initiated in Fall 1992, including the implementation of nutrient management plans on more than 735,000 acres of cropland. Also since Fall 1992, 18 municipalities have agreed to voluntarily begin biological nutrient removal (BNR) at their wastewater treatment plants. This represents a doubling of effort for the BNR program, and will prevent an additional 1.5 million pounds of nitrogen per year from entering the Bay.

Progress in the water. Improvements in water quality and living resources from efforts begun ten years ago illustrate the types of improvements we expect to see as the Tributary Strategies are fully implemented. Actions taken since 1985 are estimated to result in a 23% decrease in loads of controllable nitrogen and a 38% decrease in phosphorus reaching the Bay. This reduction in nutrient pollution has in turn contributed to a significant increase in the coverage of aquatic grasses.

Institutional progress. State agencies initially encountered some suspicion and resistance from local governments and landowners who were concerned that this comprehensive, watershed-based approach might lead to additional state regulations. However, affected groups were brought into the process early, and had significant input into the Strategies that were ultimately developed. Today, local governments have made a strong commitment to the Tributary Strategies. Given their important role in implementing many of the practices called for in the Strategies, this committment is a key sign of the Strategies success to-date. In 1993, the Governor and elected officials from each of Maryland's twenty-three counties signed a "Partnership Agreement" formally promising to work cooperatively to restore the Bay's tributaries.

Challenges Ahead

Adopting a watershed approach to nutrient reduction statewide is a complex endeavor; even more so when all of the key stakeholders are involved in decision making. The following challenges are among those that have emerged to date, and must be gradually resolved as the process continues.

Guiding the Process: Too much or too little? State agencies aim to act as facilitators to the Teams, rather than directing them toward specific objectives or activities. However, particularly at the beginning of the process, many Team members felt the need for more direction, and were uncomfortable with a "self-directed team" approach. The lead state agency for each Team has had to balance providing sufficient guidance with allowing the Team to develop ownership of the process and begin making its own decisions.

Cultivating Team leaders. Having strong Team leaders is essential for moving the Teams toward action. In order to get the Teams started, the State appointed Interim Chairs, with the specification that they would act as Chair for six months, until the Team chose to select a permanent Chair. In addition, some Teams have benefitted from additional leadership by forming subcommitteees and selecting subcommittee Chairs to move the Team forward on particular issues.

Team Buy-In. Many team members were selected from among those who attended public meetings to discuss the Tributary Strategies as they were being developed. However, some team members were new to the process, and lacked both the technical background and the history associated with developing the Strategy for their Tributary. As a result, there have been many questions about the technical basis for the Strategies (e.g., the computer modeling that was used to set nutrient loads and reduction goals). Most of the Teams have both members who want to spend more time understanding the problems and the proposed solutions, and those who are impatient to move toward action. Team members are being asked to help implement the Strategy. But first, all members need to understand and accept the Strategy.

Funding. The Strategies outline a package of best management practices that, when implemented, will lead to a 40% reduction in nutrients in each Tributary. Many of these practices are funded through existing programs, but will require additional funding for increased implementation. To address this need, the Governor appointed a Blue Ribbon Panel of experts from the disciplines of finance, business, and government to identify new ways to finance environmental projects. While the Panel's report identifies dozens of new approaches, some of which are being further explored by State agencies, funding remains a persistent question that needs to be addressed by all parties.

Growth. The 40% reduction in nutrients is not only an ambitious goal, but is a cap. Under the 1987 Agreement, once nutrients are reduced to 60% of 1985 levels, they will not be allowed to increase. With portions of the State developing rapidly, managing growth in ways that minimize its impacts on water quality will be a continuing challenge. Maryland has growth management legislation, but most land use decisions remain at the local government level, making local planning issues a key part of the Tributary Strategies.

Working with elected officials. In the current climate of budget cutting, environmental programs need to demonstrate their importance for quality of life, health, and economic vitality. Maryland is working to inform both state legislators as well as elected officials at the county and town level of the importance of watershed planning and water quality goals. A local government liaison works closely with both elected officials and staffs to provide information and act as a sounding board for local government concerns. With elected officials constantly turning over, this effort must be coordinated and continuous.

State goals v. Local goals. The Teams were created to help implement a goal that had been set by the Chesapeake Bay Program. This goal can be met statewide through a collection of practices implemented at the local level, which will also improve local water quality and habitat. Many of the practices recommended_such as creating forest buffers, improving stormwater management, and managing animal waste_clearly have both nutrient reduction benefits, and benefits for local water quality. However, several teams have identified a potential tension between local priorities (e.g., habitat restoration, and reservoir protection) and the State's focus on nutrient pollution, the primary problem in the estuary. This is currently being addressed by focusing on the many areas where State and local priorities overlap. Some teams may also choose to expand their mission to look at a broader set of goals than the current nutrient pollution focus.

Understanding the Team's role. Before the Teams were formed, State and local government staff working on their creation drafted a mission statement and guidance document outlining the Team's role in helping to implement the Strategies. In practice, however, the Team's role has been a learning process for all parties. The different levels of knowledge of the Strategies, as well as the broadness of the Team's mission have led to frustration within some groups. This can be compounded with confusion about the many existing programs that are working on aspects of the nutrient reduction problem. The Teams wonder_where do we fit in? Currently, this issue is being addressed by focusing both on Team forming subgroups that allow the more activist members to begin examining issues and identifying actions, and allow those who want more familiarity with the Strategies to take time to review the progress made to-date.

Maintaining private sector involvement. The Teams were formed to represent all the major stakeholders in each Tributary, and to encourage creative, realistic solutions based on dialogue between different interest groups. The agricultural community has been active in the formation of the Strategies from the beginning, in part because agriculture is a major source of nutrients to the Bay, and farmers have an interest in demonstrating the success of a nonregulatory approach. However, because there is no intention of producing additional legislation, the business community has been less involved in this process. It is hoped that as the Teams begin to organize local initiatives they will be able to involve more local businesses in specific "hometown" projects.

Building a watershed perspective. The Tributary basins are quite large, ranging from 269 to 2,043 square miles. Most Tributaries encompass parts of at least three counties, which, like most jurisdictions, are unaccustomed to implementing or planning on a watershed basis. The Teams provide a framework for coordination among counties, but it remains to be seen how much the watershed perspective will be integrated into day-to-day decisions.

Conclusion

Maryland's Tributary Teams have been meeting for less than one year, and are still in the beginning stages of their work. They are a key part of an approach that has never been tried before in Maryland_a long term watershed-based implementation effort that seeks to accomplish both Chesapeake Bay Program nutrient reduction goals and local water quality objectives. It is not yet clear where the balance between a state-directed and a locally-driven approach will be struck. What is clear is that the Tributary Teams offer an opportunity to rethink traditional approaches toward improving water quality, and could greatly expand the constituency for watershed protection.